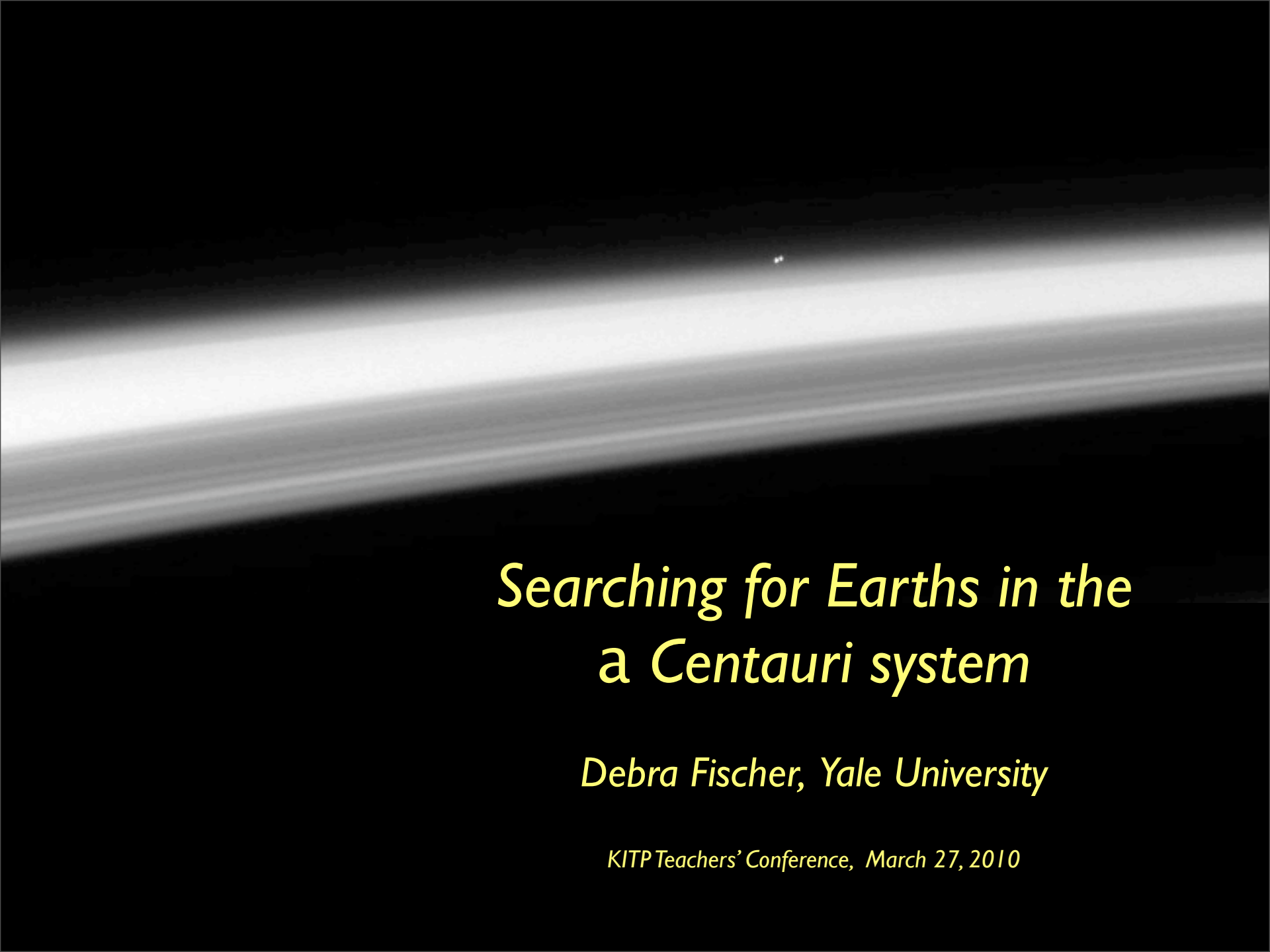


Searching for Earths in the a Centauri system

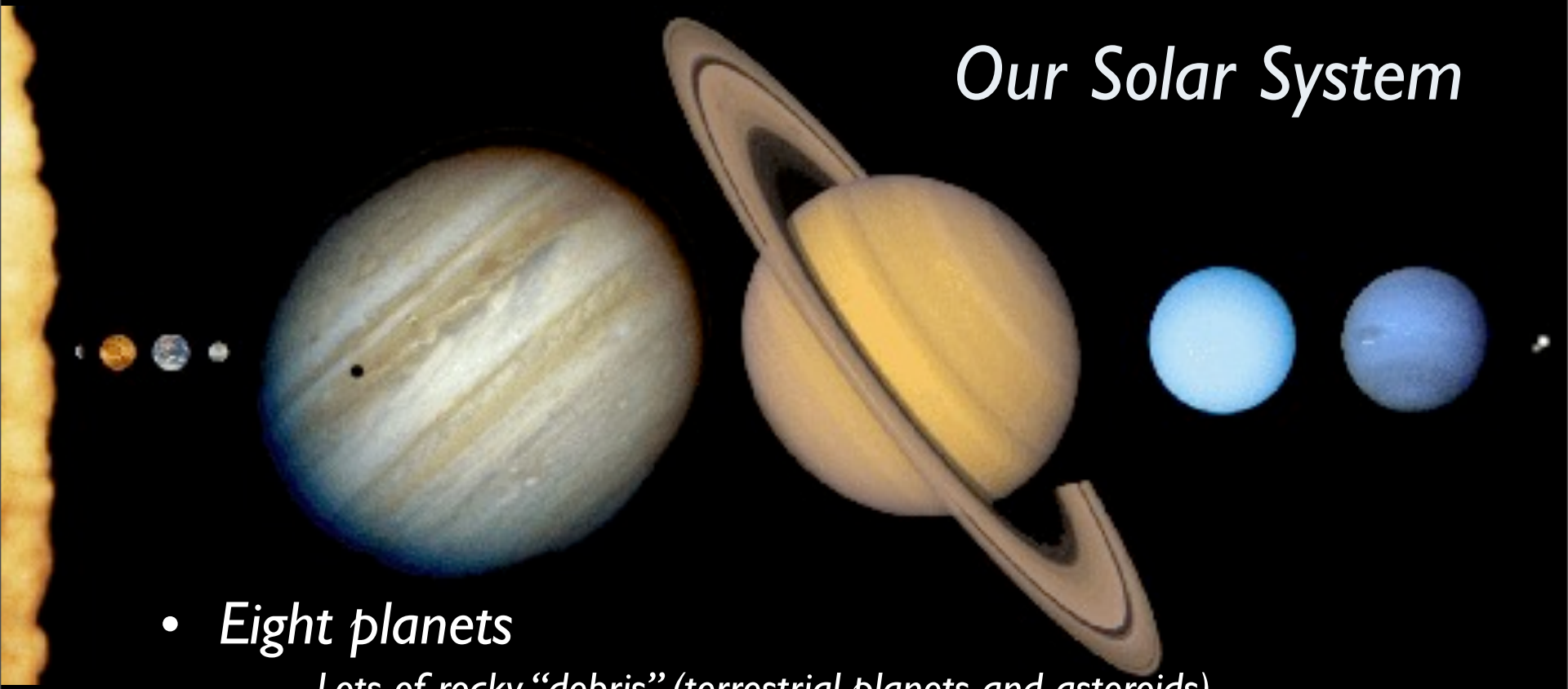
Debra Fischer, Yale University

KITP Teachers' Conference, March 27, 2010

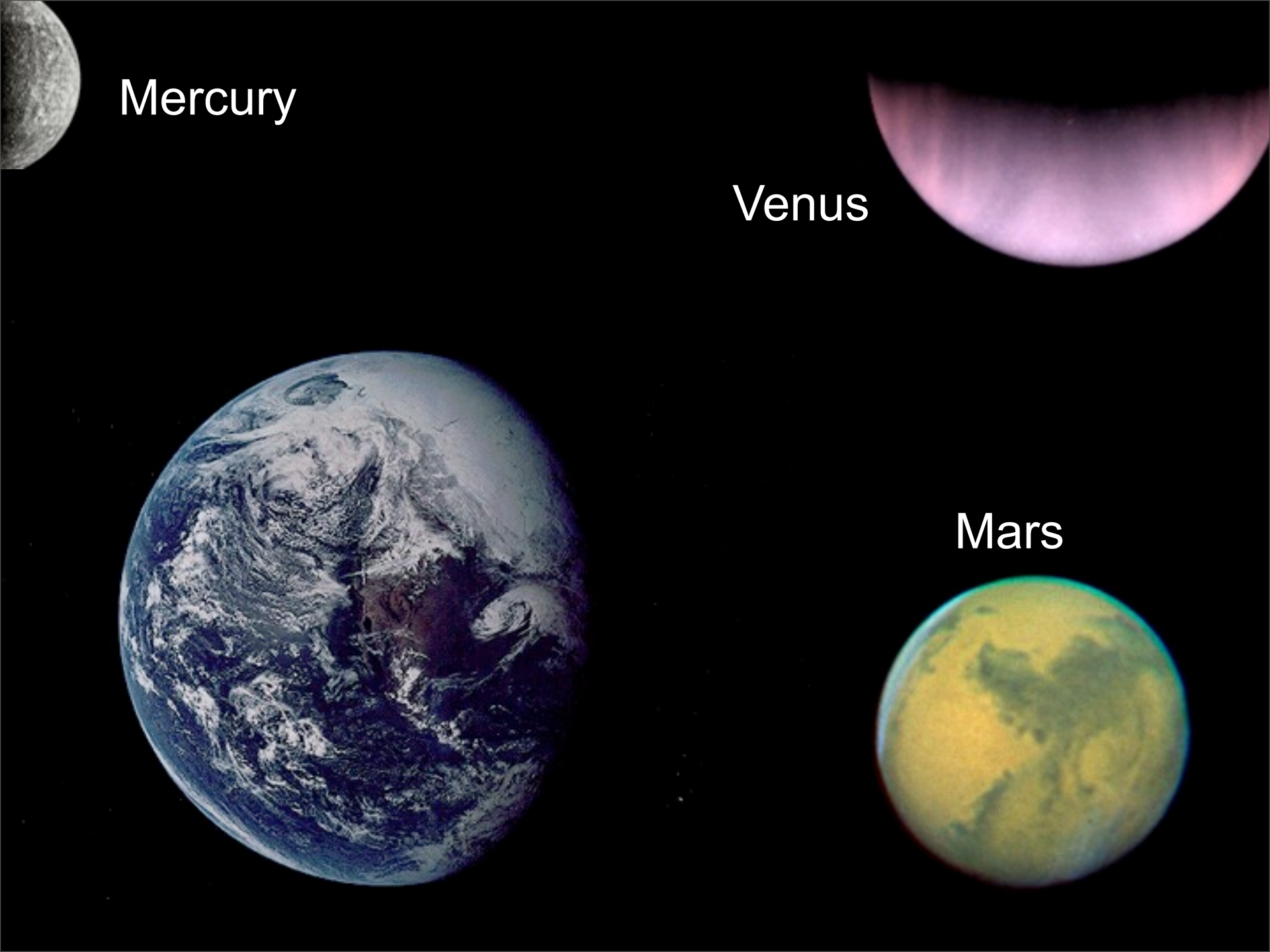
First, a little perspective.

Our Solar System

Our Solar System

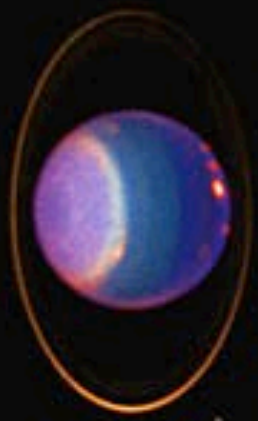


- *Eight planets*
  - *Lots of rocky "debris" (terrestrial planets and asteroids)*
  - *Most planets have moons*
- *Nearly circular orbits*
- *Only one inhabited planet*


Mercury
Venus
Mars

Jupiter = 317 earth masses

Uranus = 14 earth masses



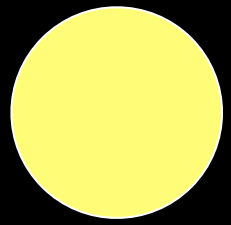
Saturn = 95 earth masses

Neptune = 17 earth masses

Scale of things...
Radius of Sun = 695500 km
Radius of Earth = 6378 km
Distance between Earth-Sun = 149598000 km

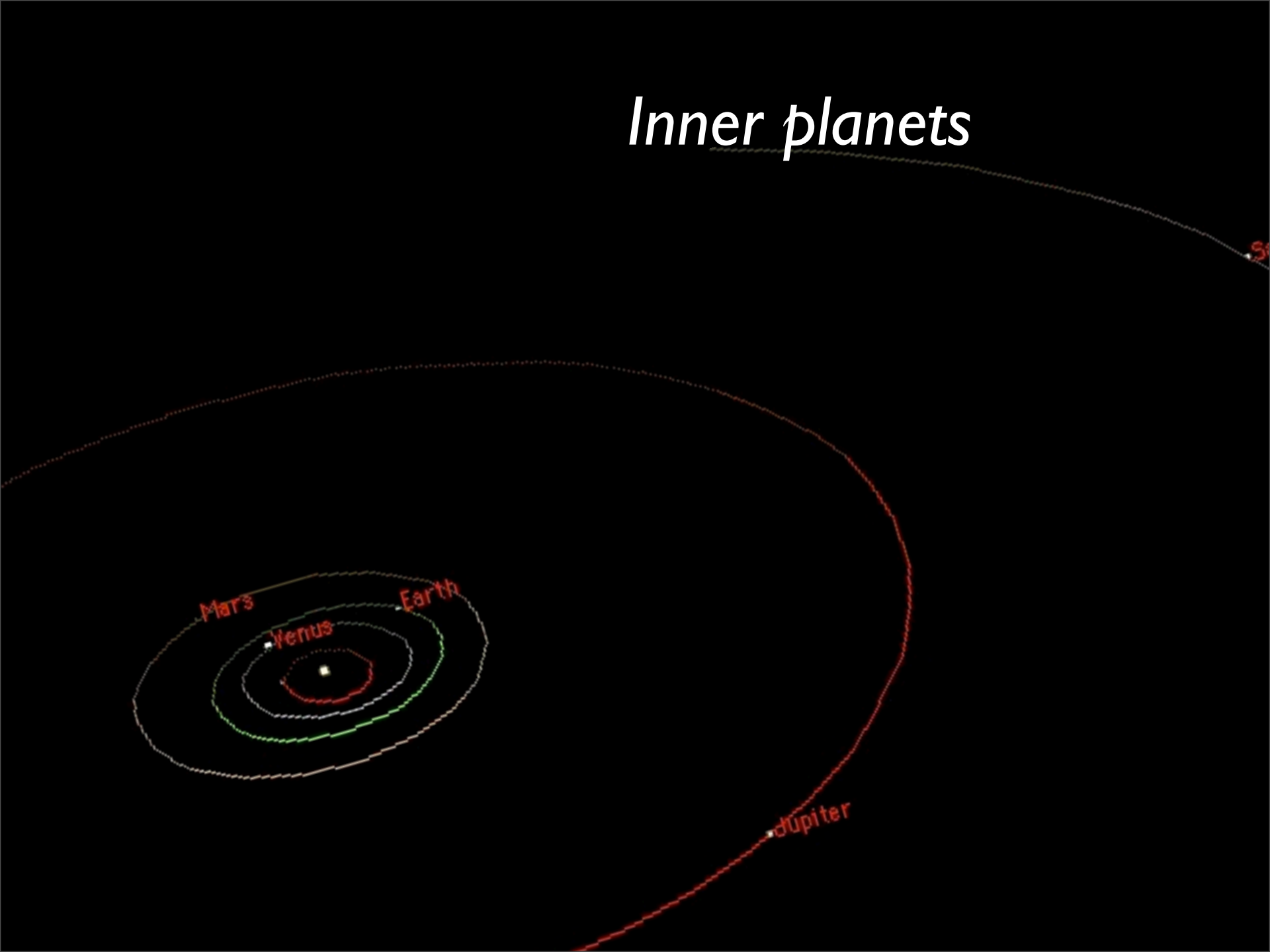
In units scaled to the solar radius:
Radius Sun = 0.5 m
Radius of Earth ~ 0.5 cm “coffee bean”
Dist b/t Earth-Sun ~ 100 m = 100 giant steps

coffee-bean Earth

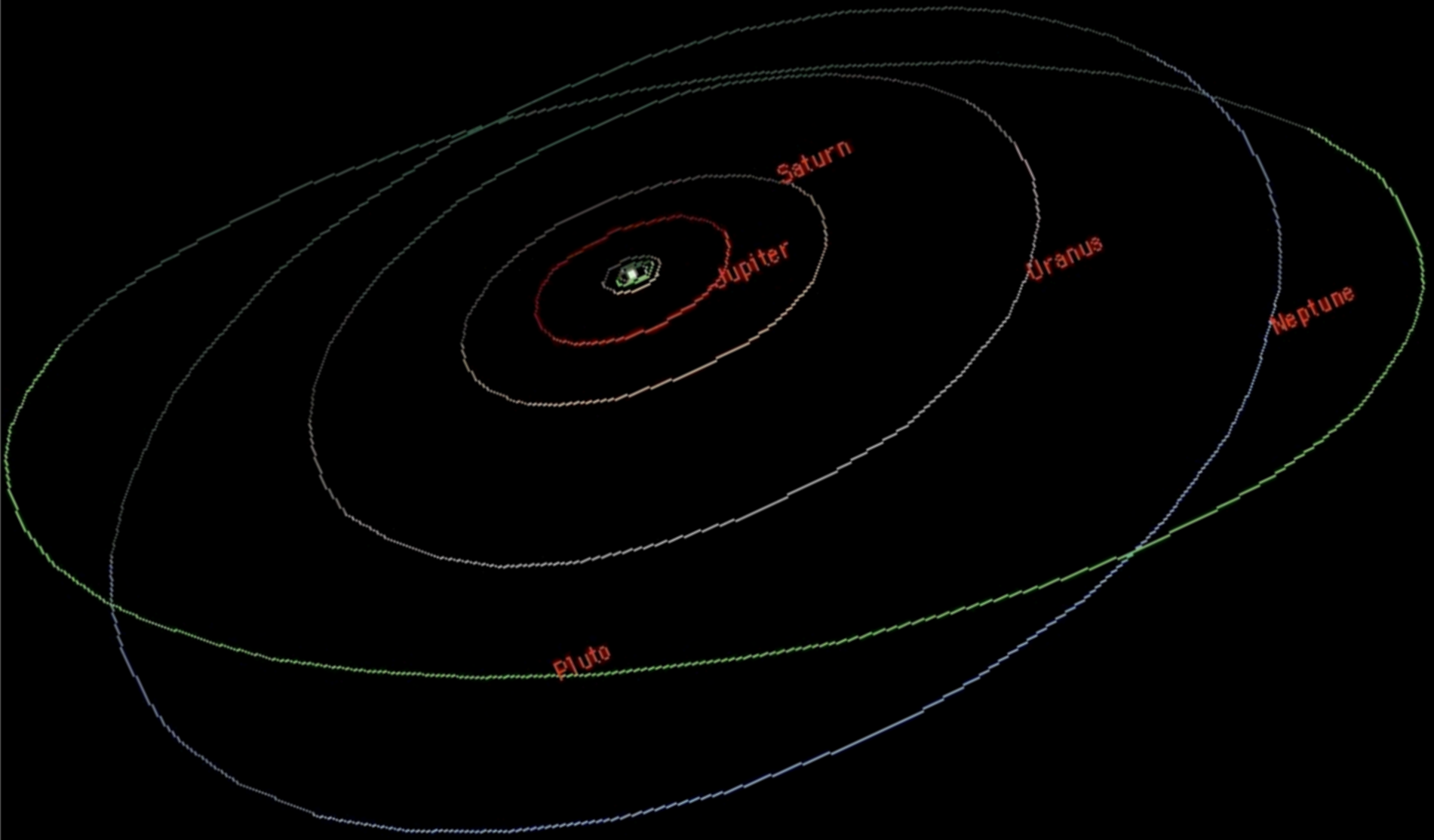


coffee-bean Earth

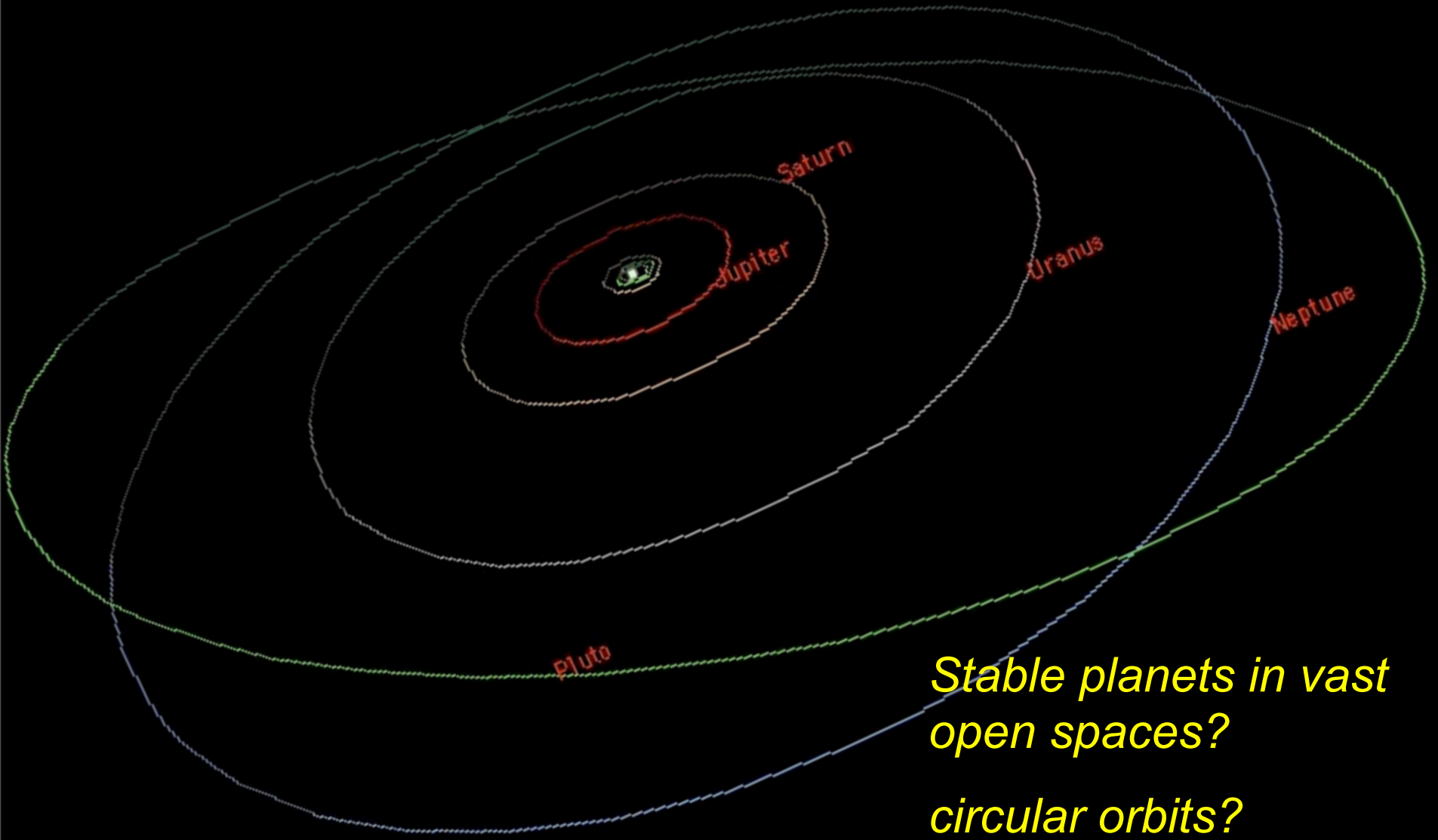
Inner planets



Outer Planets



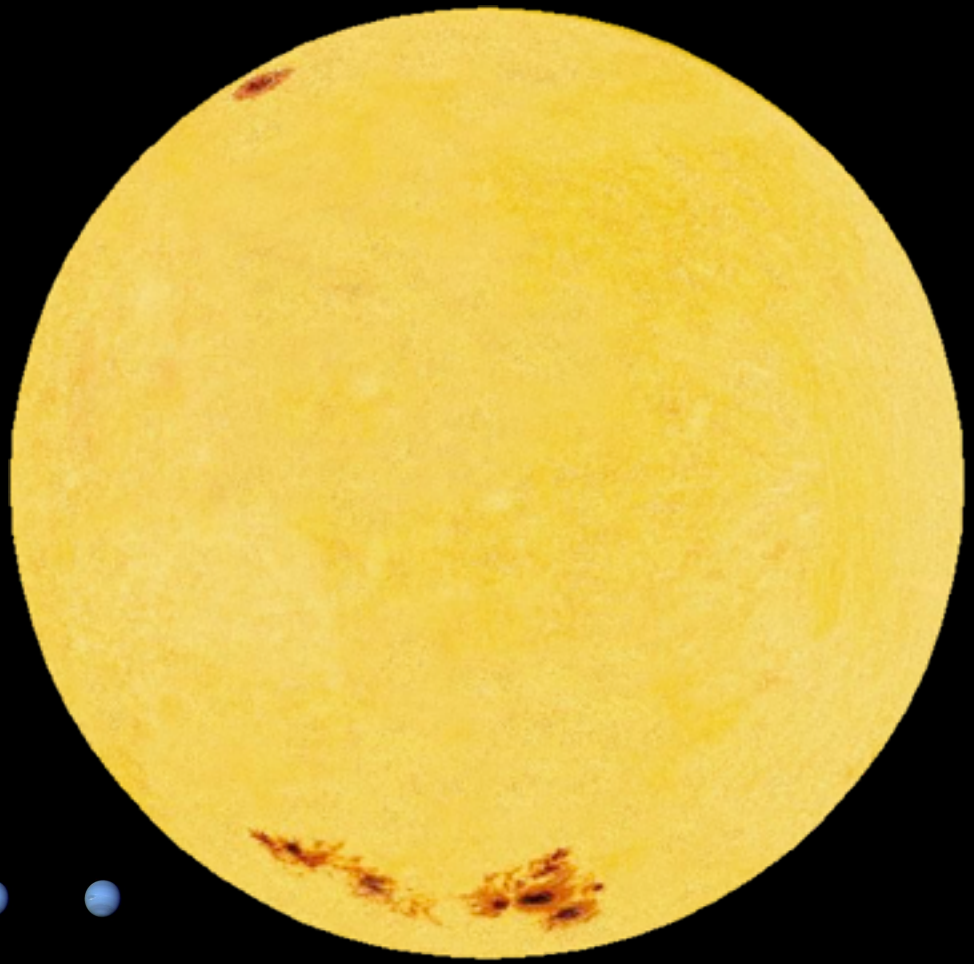
Outer Planets



Stable planets in vast open spaces?

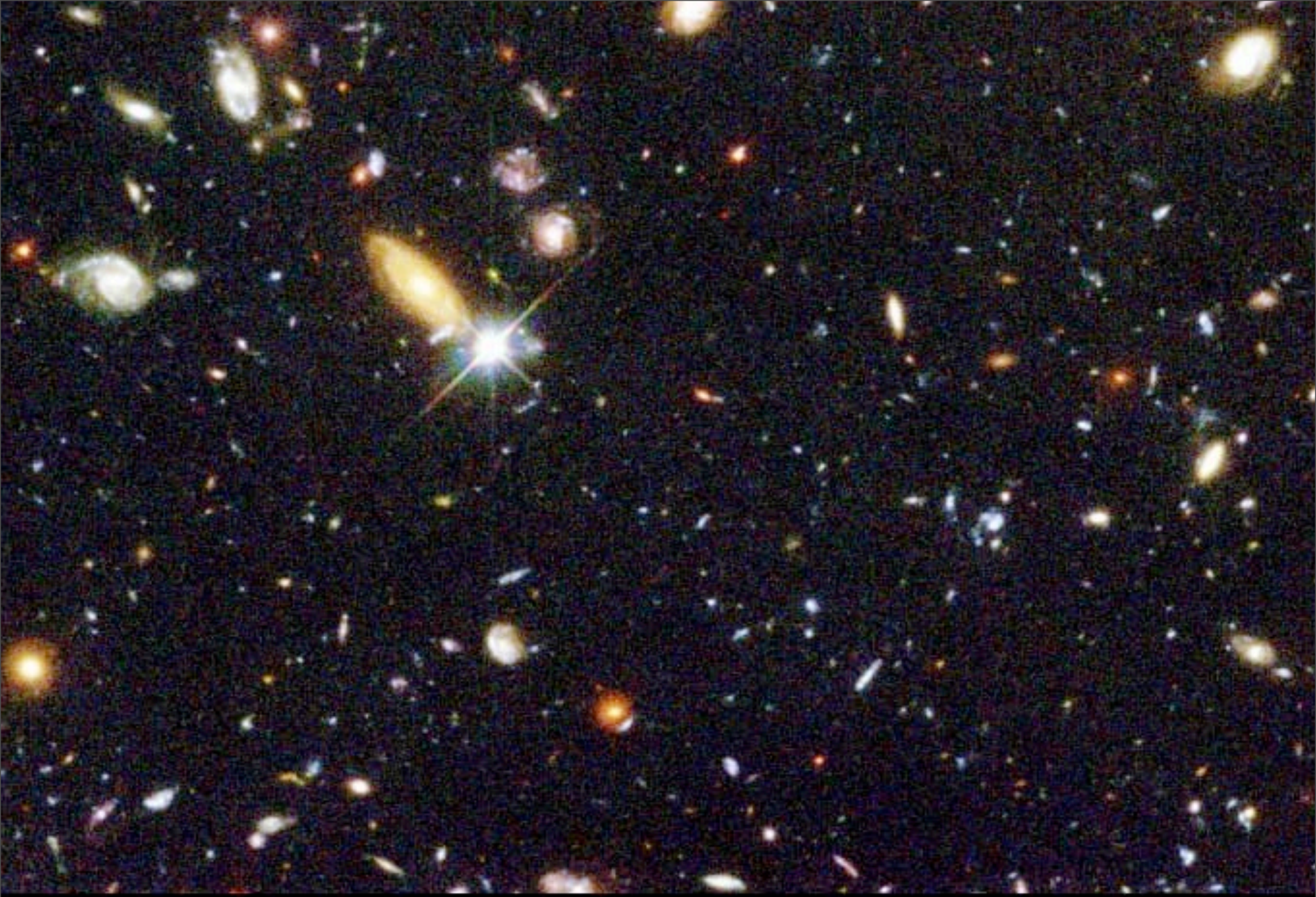
circular orbits?

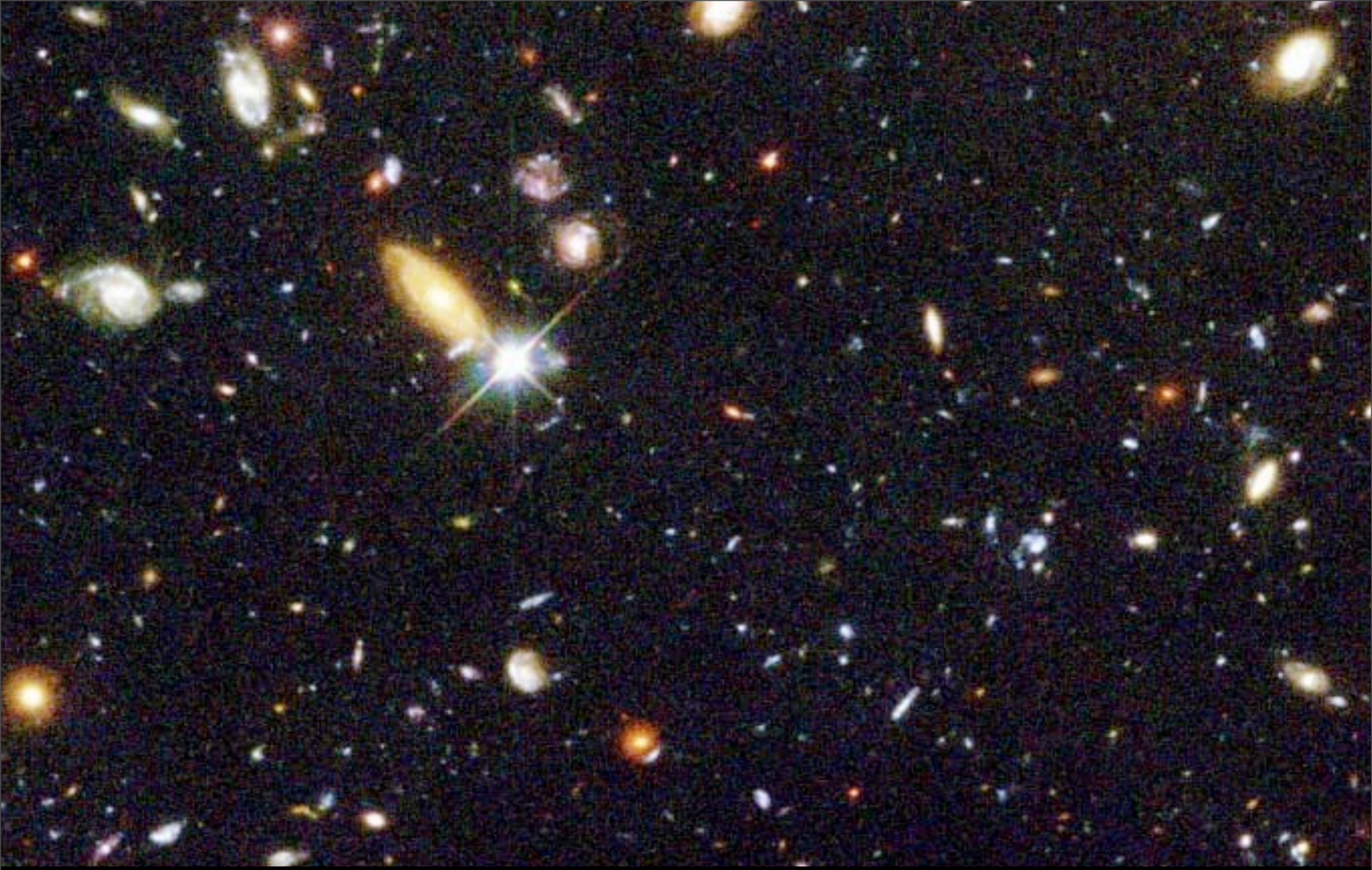
Planets vs Stars....



Earth Mars Jupiter Saturn Uranus Neptune Sun

Our Sun appears to be an unremarkable star, like millions of others in our galaxy.


Hubble Deep Field
HST • WFPC2
PRC96-01a • ST ScI OPO • January 15, 1996 • R. Williams (ST ScI), NASA

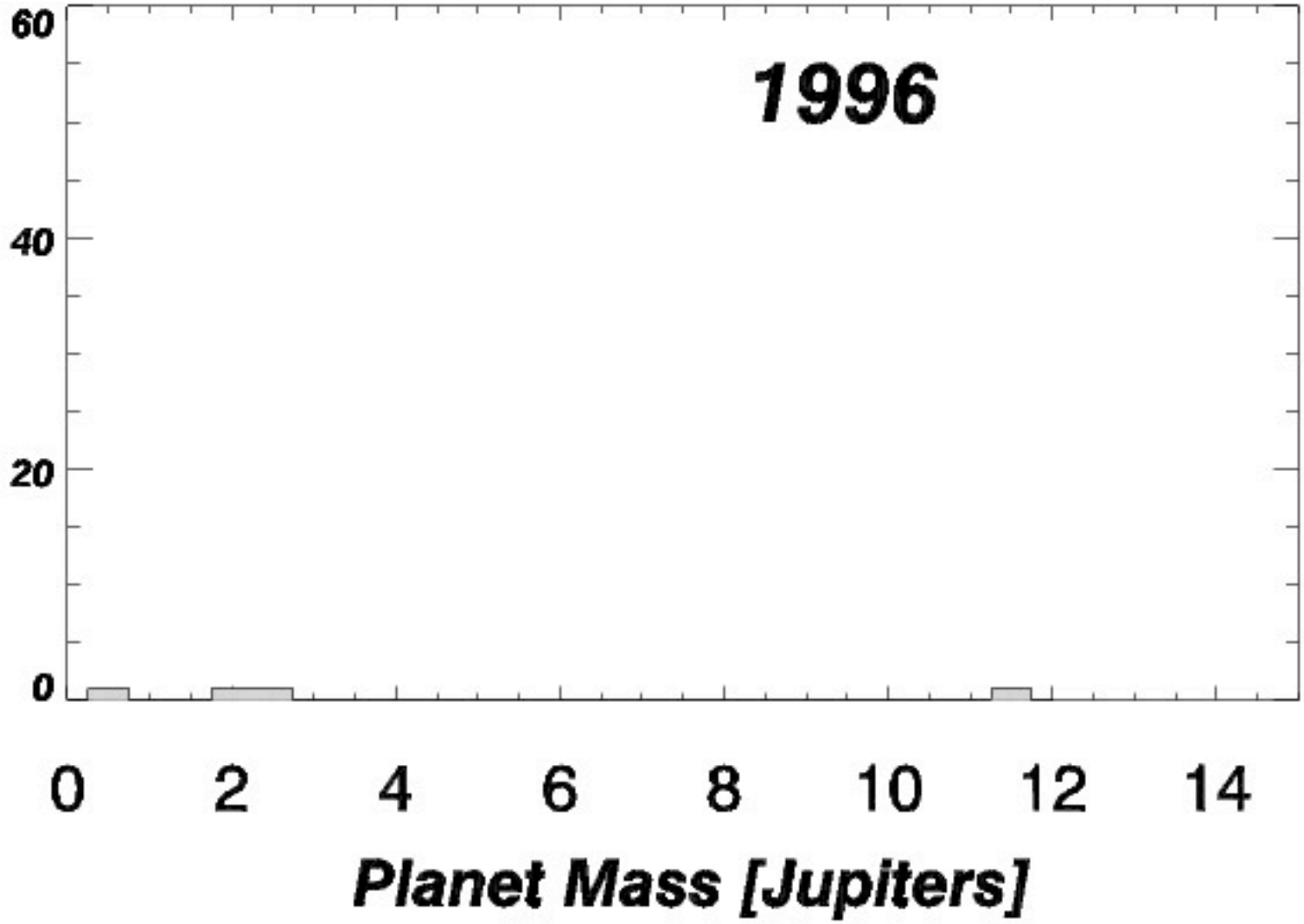


The Universe Contains Trillions of Galaxies

Hubble Deep Field HST • WFPC2

PRC96-01a • ST ScI OPO • January 15, 1996 • R. Williams (ST ScI), NASA

Mass of detected planet



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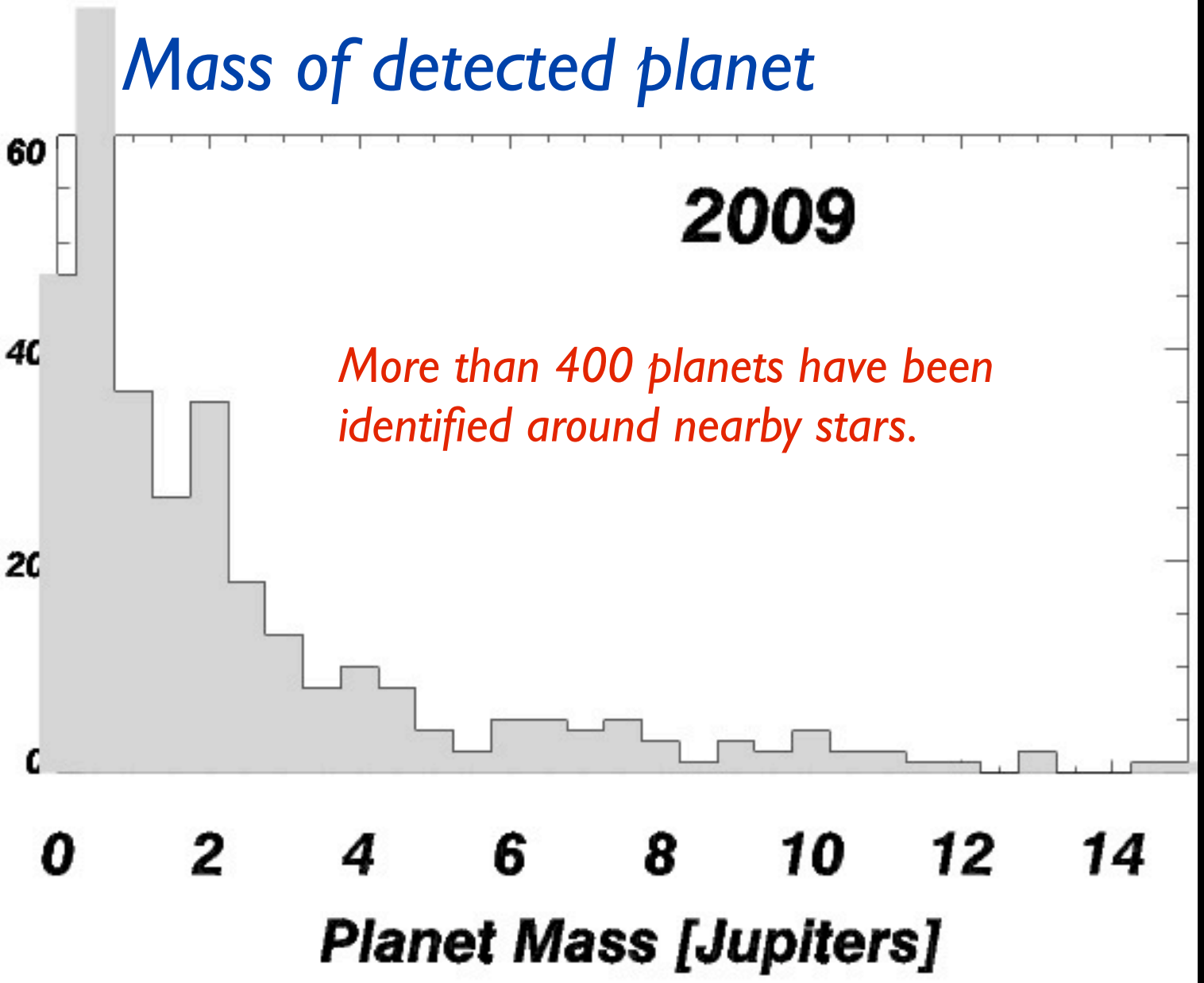
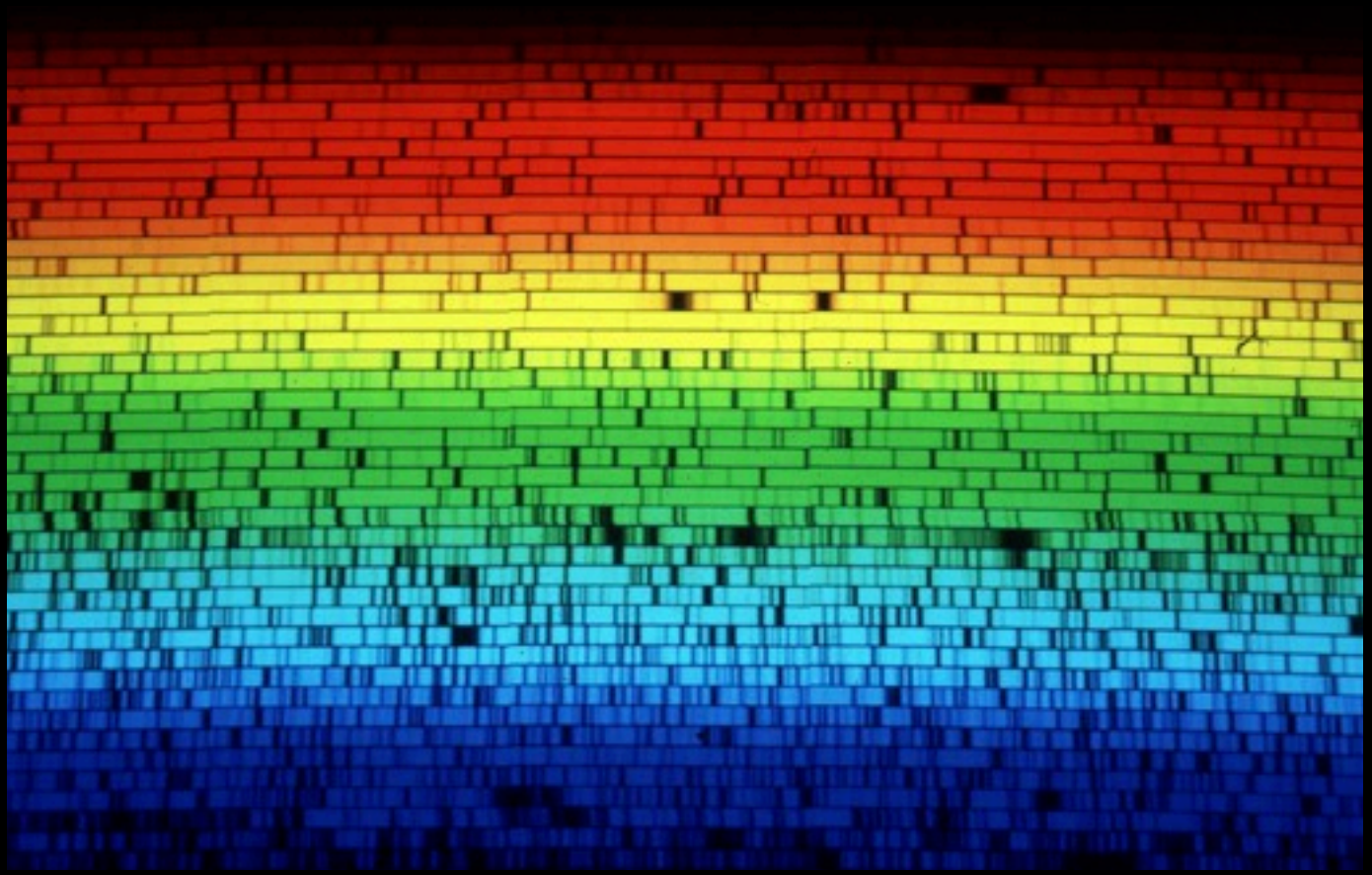


Doppler Effect: *with spectroscopy, measure change in the line of site velocity of the star - the "wobble method."*



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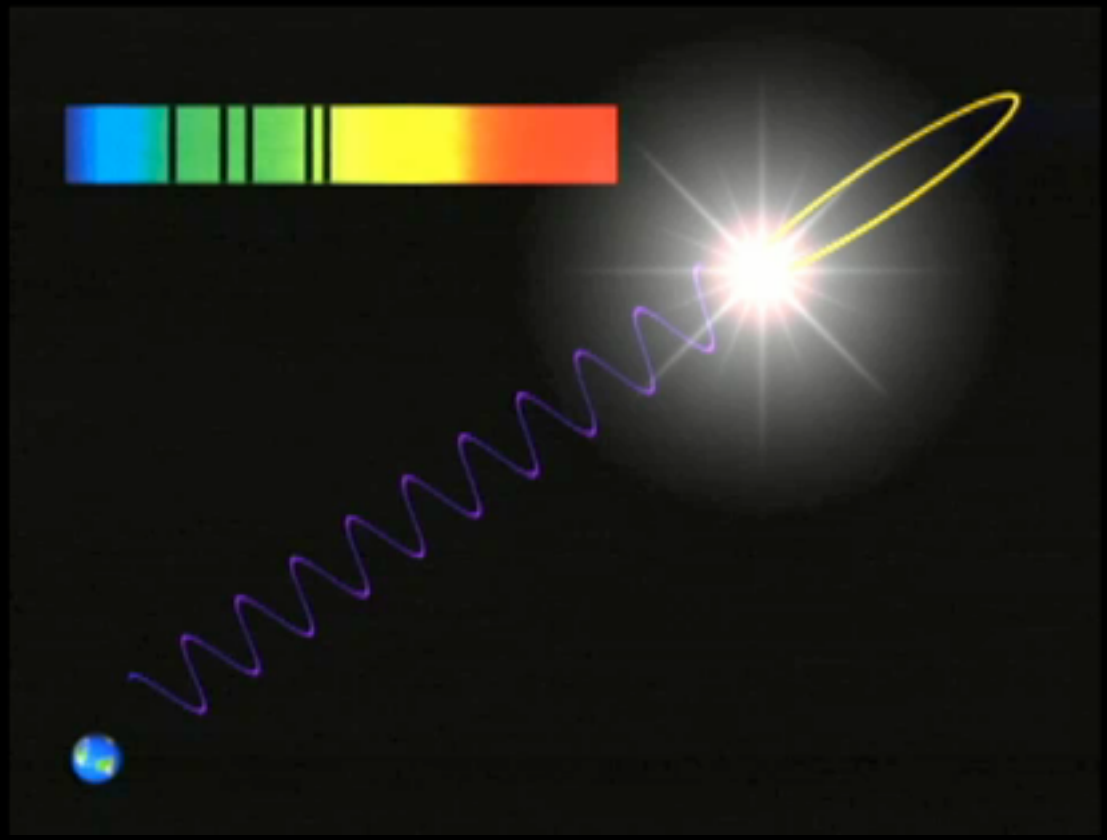

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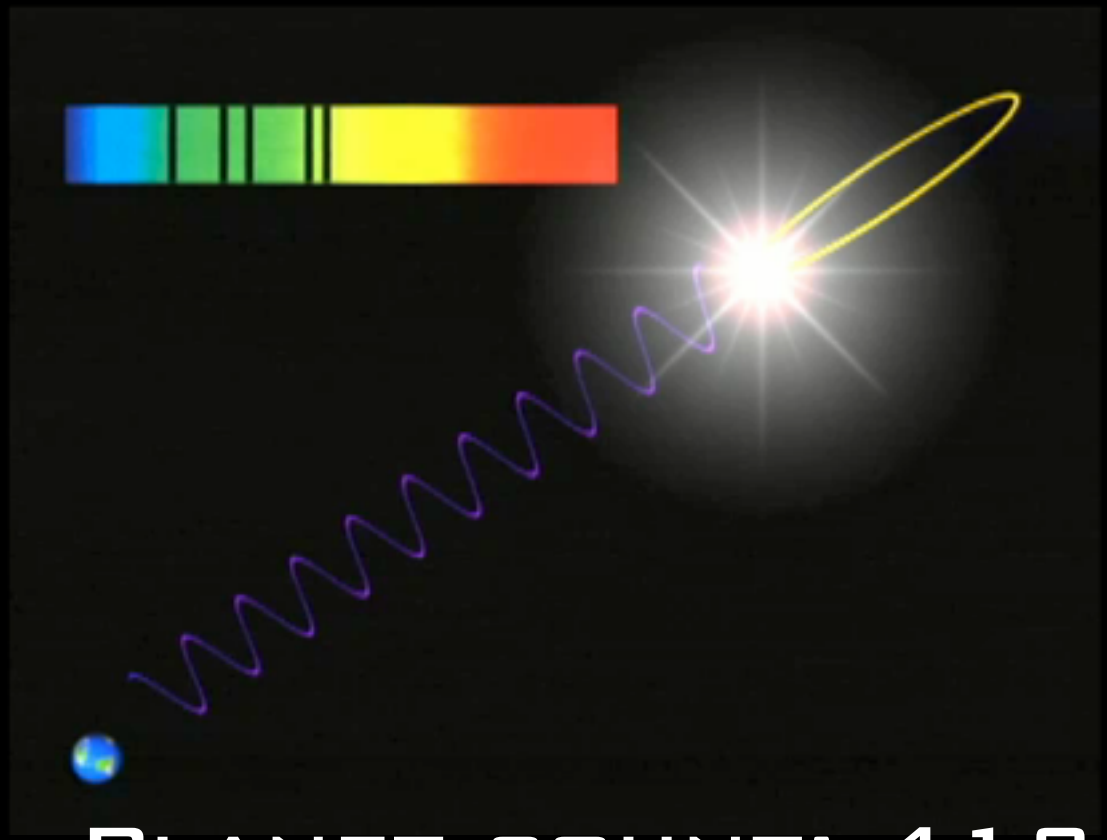
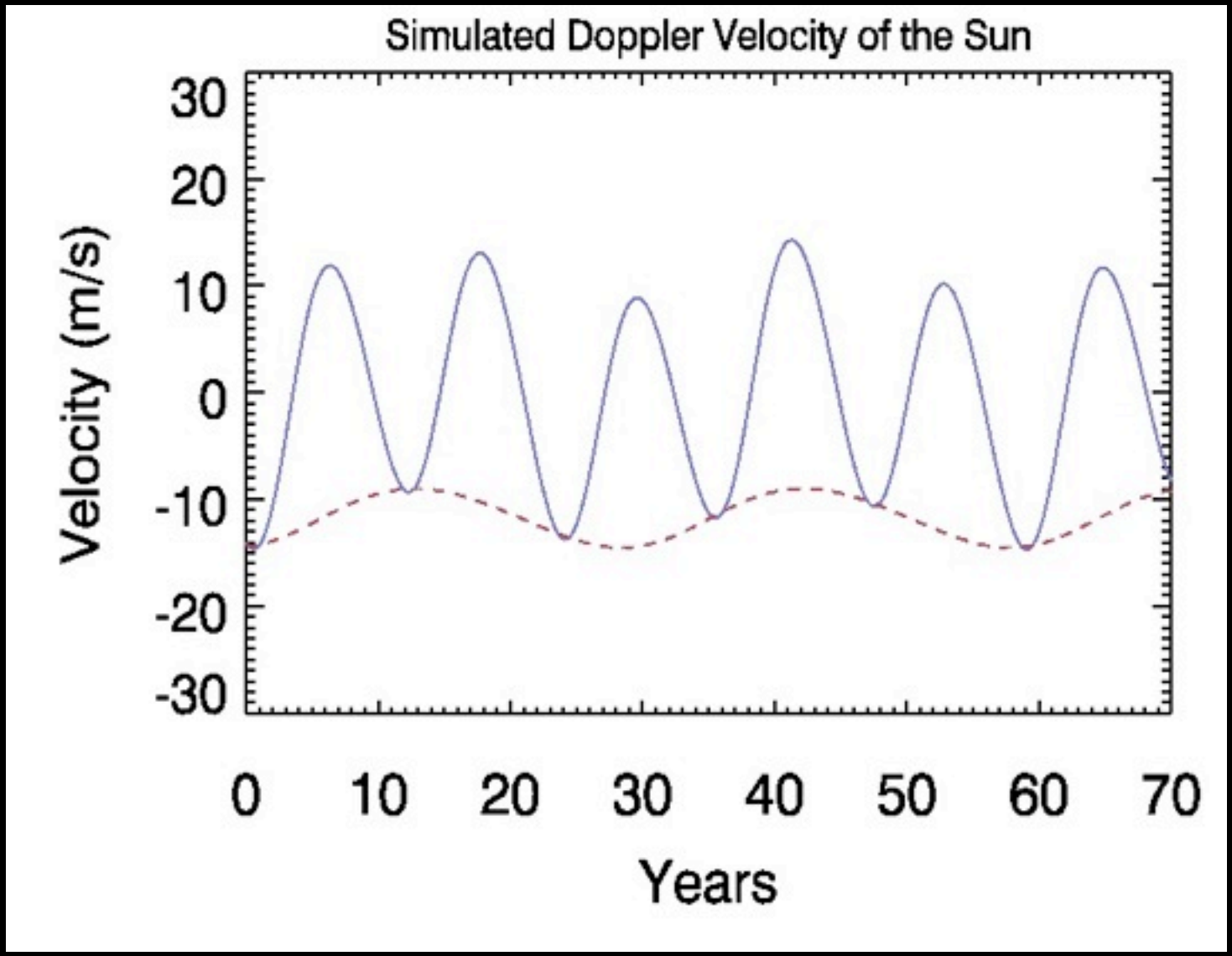
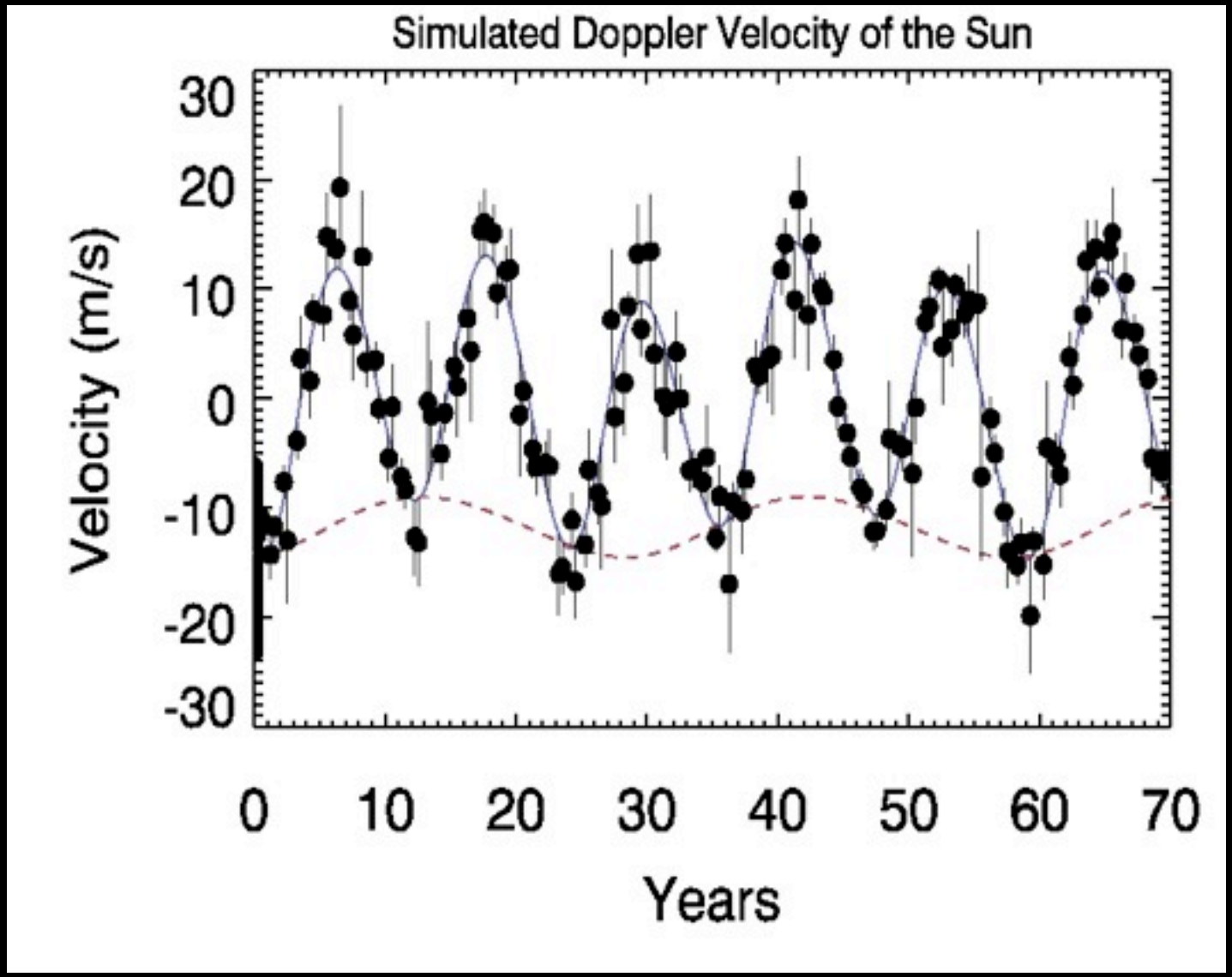
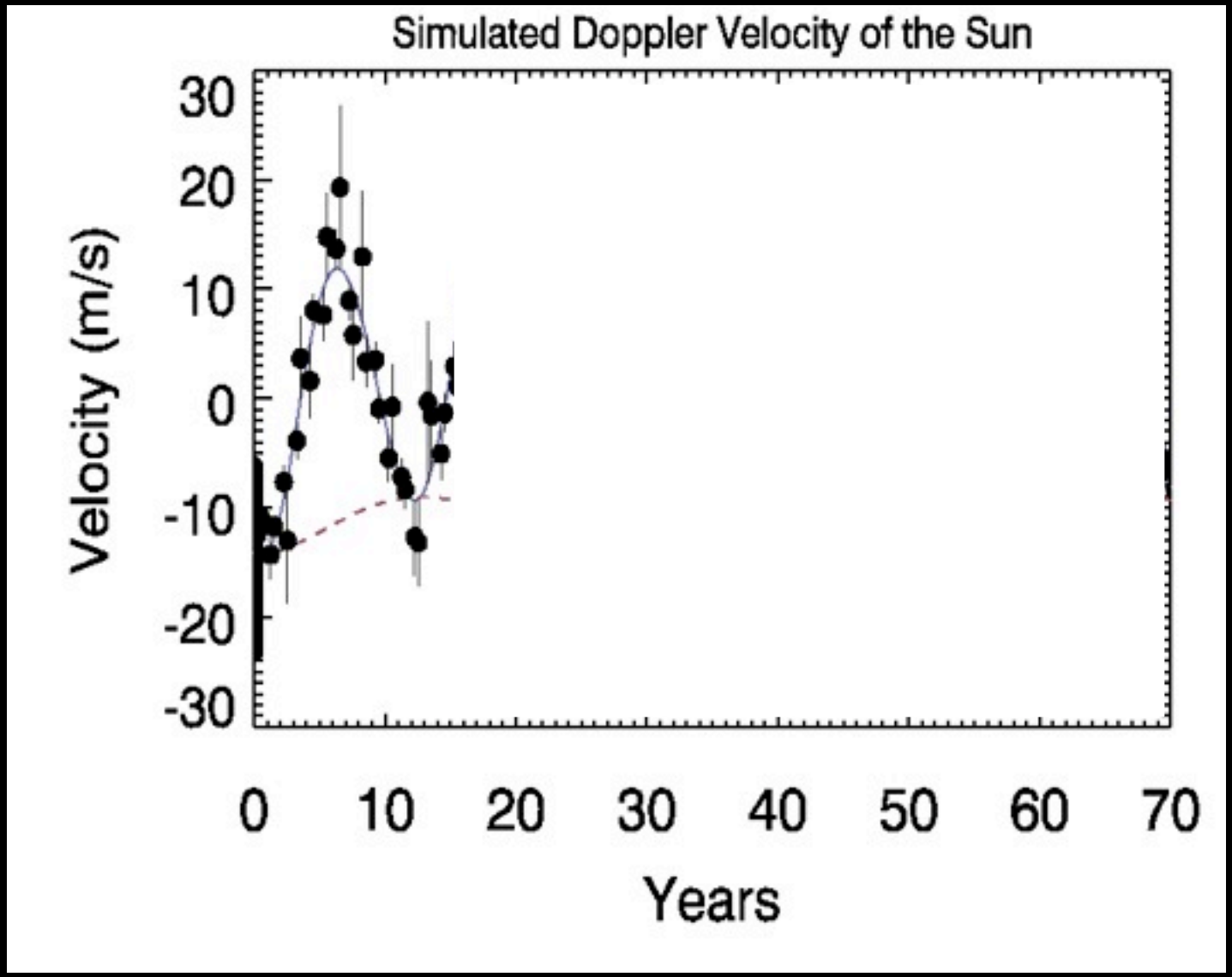


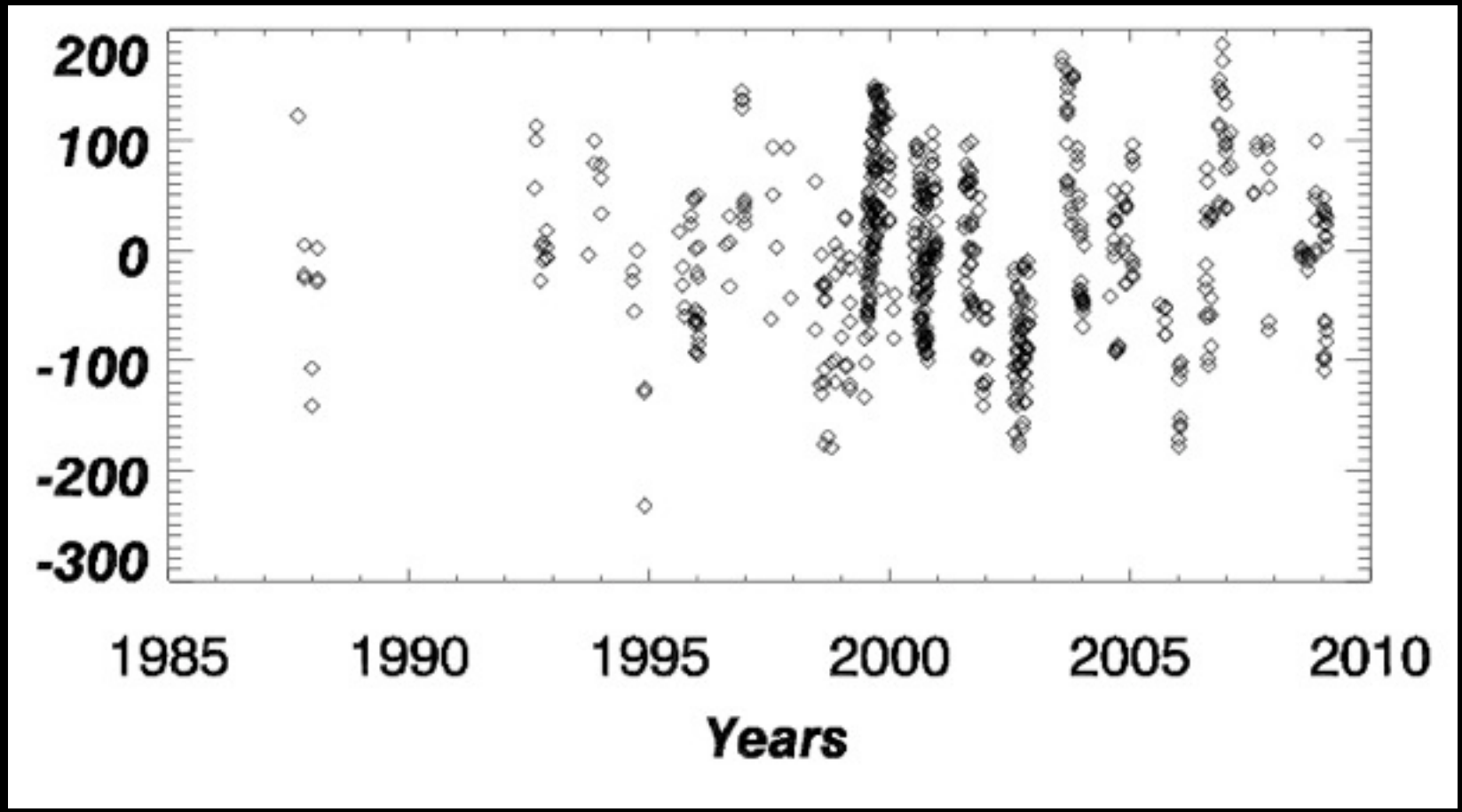
PLANET COUNT: 412


Simulated Doppler Velocity of the Sun
Velocity (m/s)
30
20
10
0
-10
-20
-30
0
10
20
30
40
50
60
70
Years

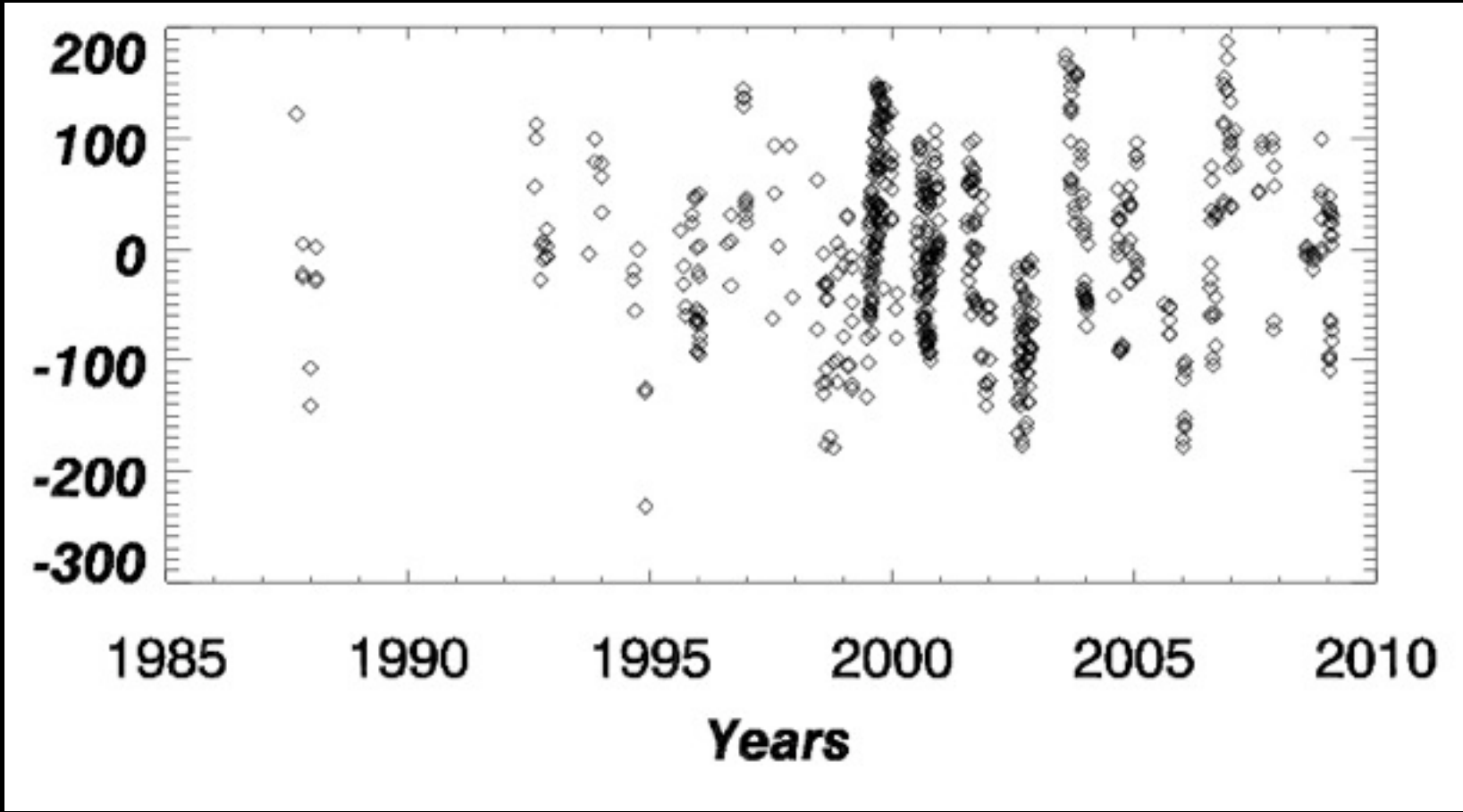

Simulated Doppler Velocity of the Sun
Velocity (m/s)
30
20
10
0
-10
-20
-30
0
10
20
30
40
50
60
70
Years

Observation span: 1995 to now...

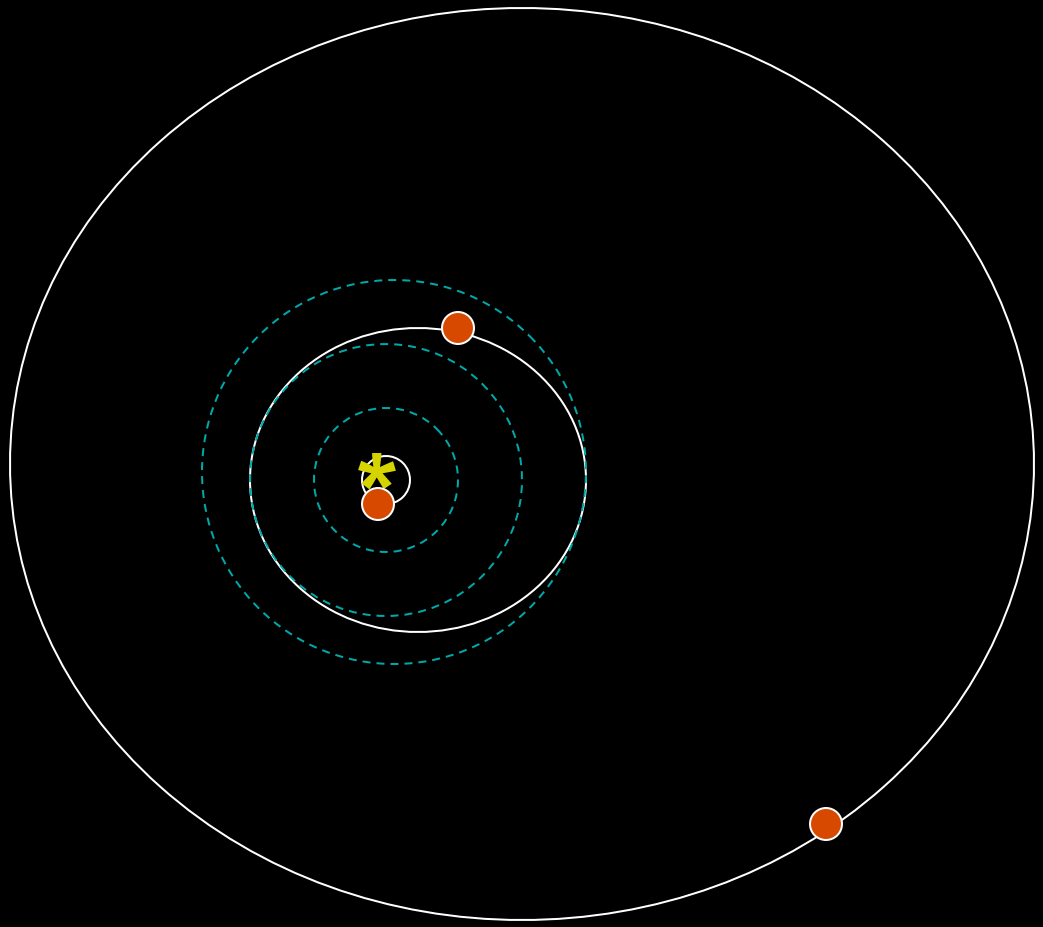



200
100
0
-100
-200
-300
1985
1990
1995
2000
2005
2010
Years

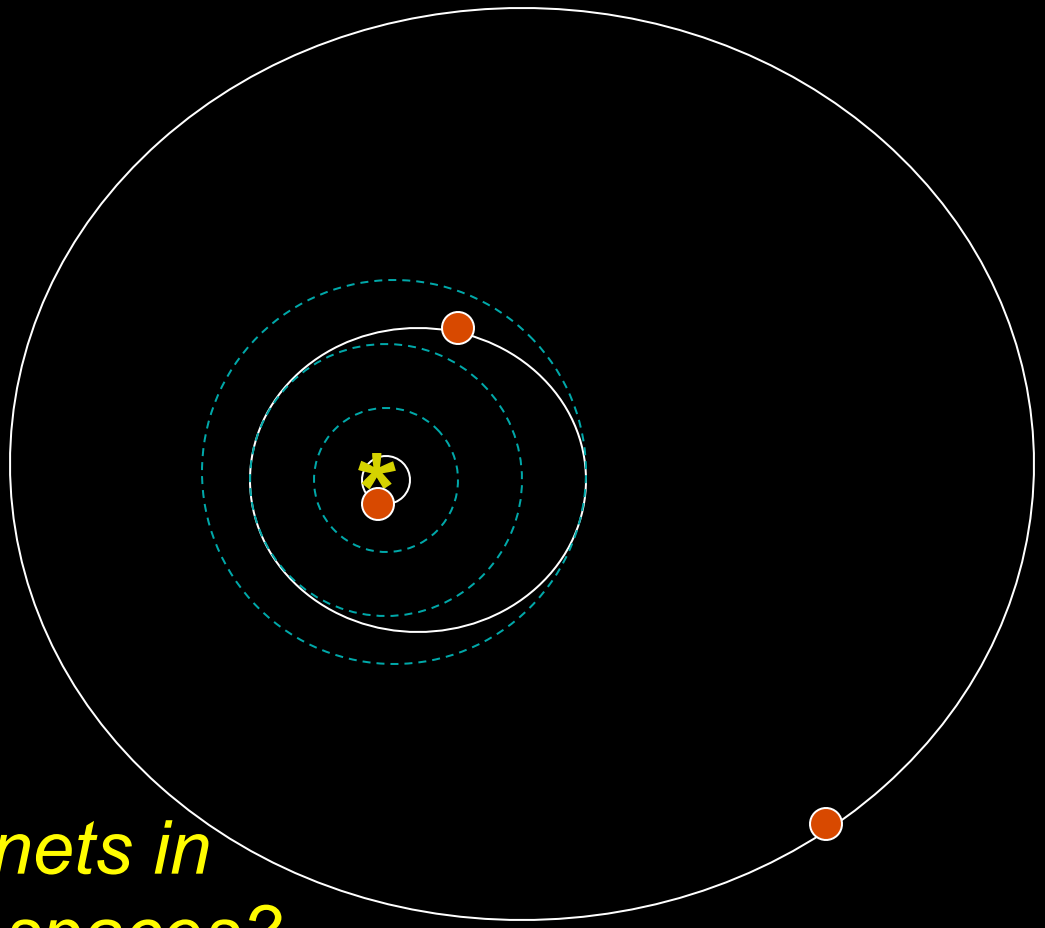
How many planets around this star?



Upsilon Andromedae



Upsilon Andromedae



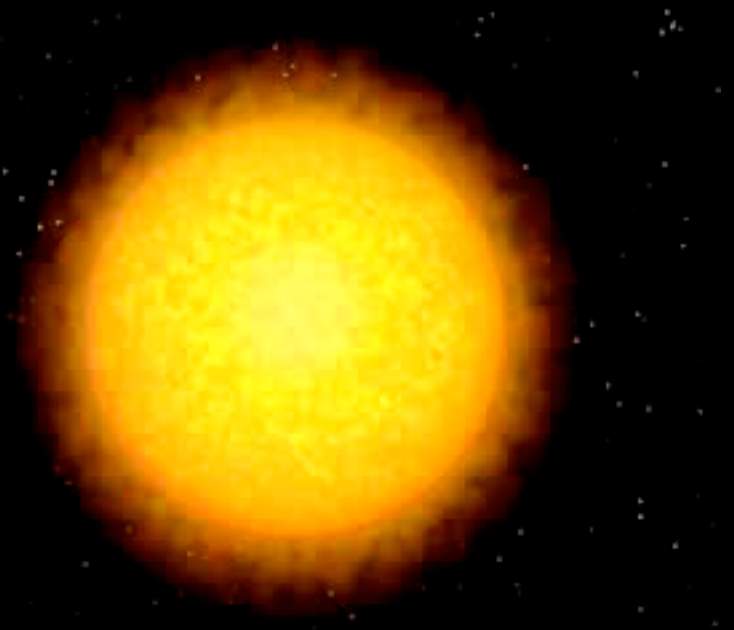
Stable planets in vast open spaces?

circular orbits?

Multiple planet systems are not just an odd curiosity. Many of the systems we are finding appear to have more than one detectable planet!

Artists rendition, by Lynette Cook

Many scientists were skeptical about the interpretation of the data. However, we knew that one day, the orbit of one of these planets would be oriented so that it transited in front of it's host star.



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Of these observational techniques,
how many will find “Earths”?

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how many will find “Earths”?

Microlensing (10)?

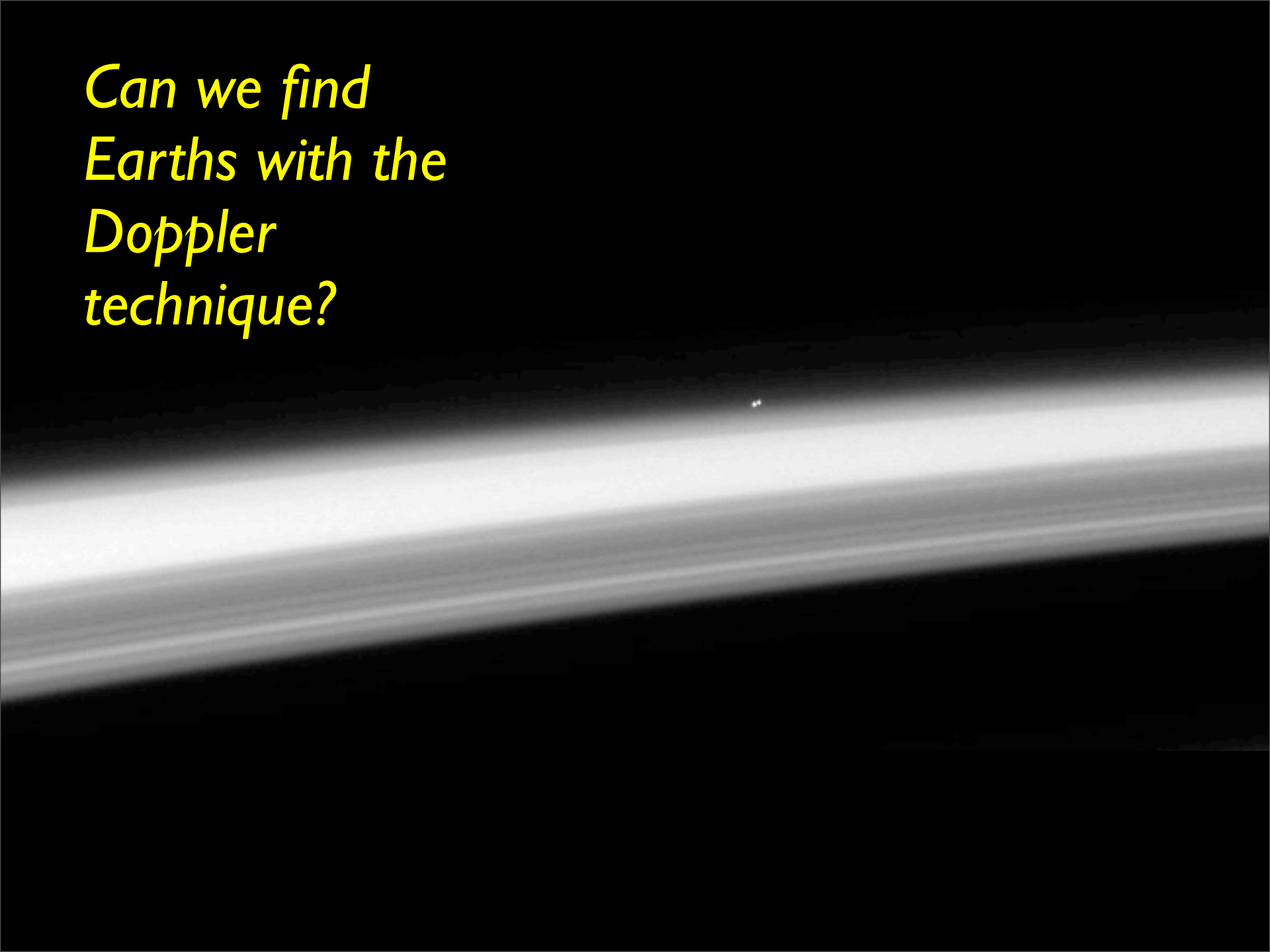
Transits with Kepler (5)?

Transits with ground-based telescopes (66)?

Doppler observations (412)?

Imaging (11)

How will we find ***many*** “Earths”?


Can we find Earths with the Doppler technique?

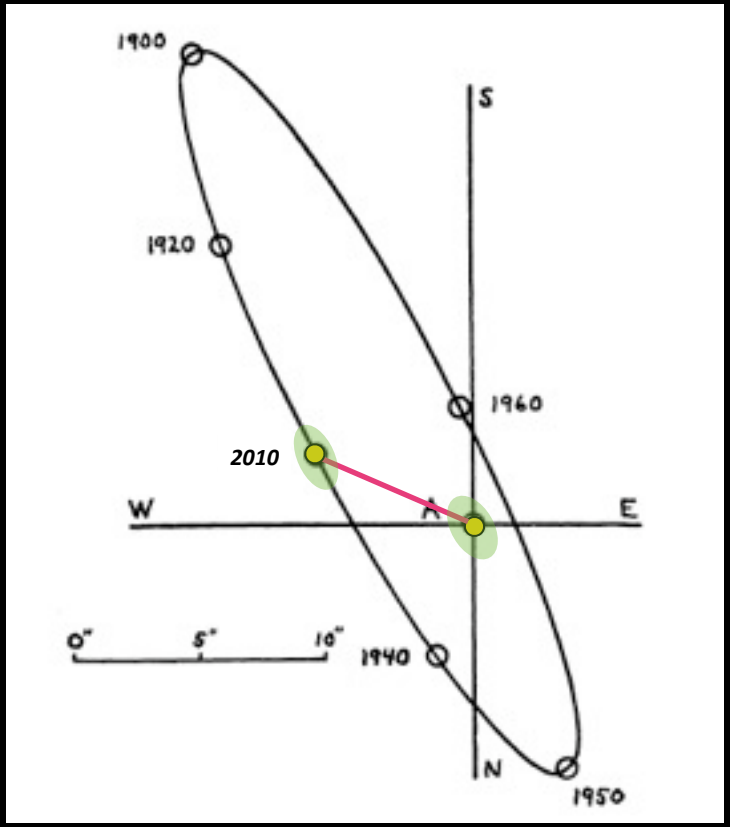
Leaflet No. 222—September, 1947

• • •

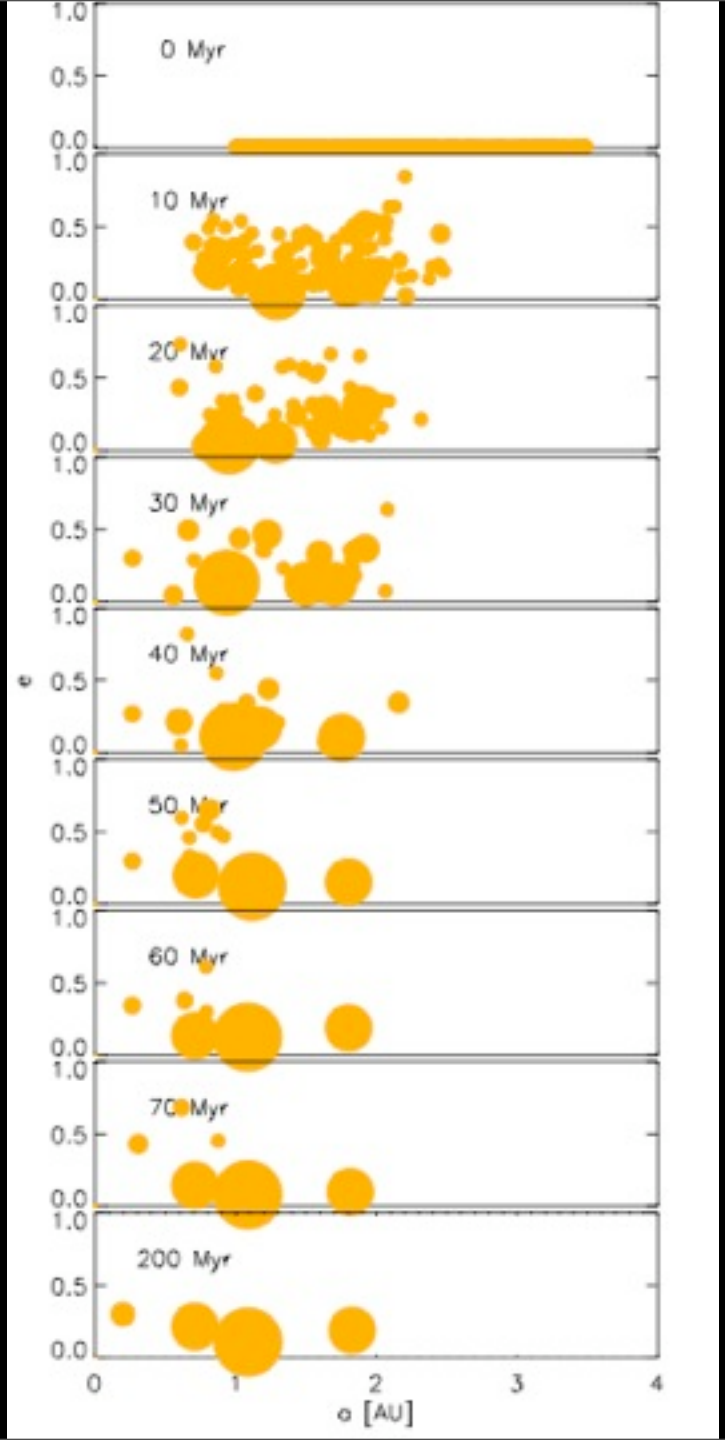
OUR NEAREST STELLAR NEIGHBOR

By Roscoe F. Sanford

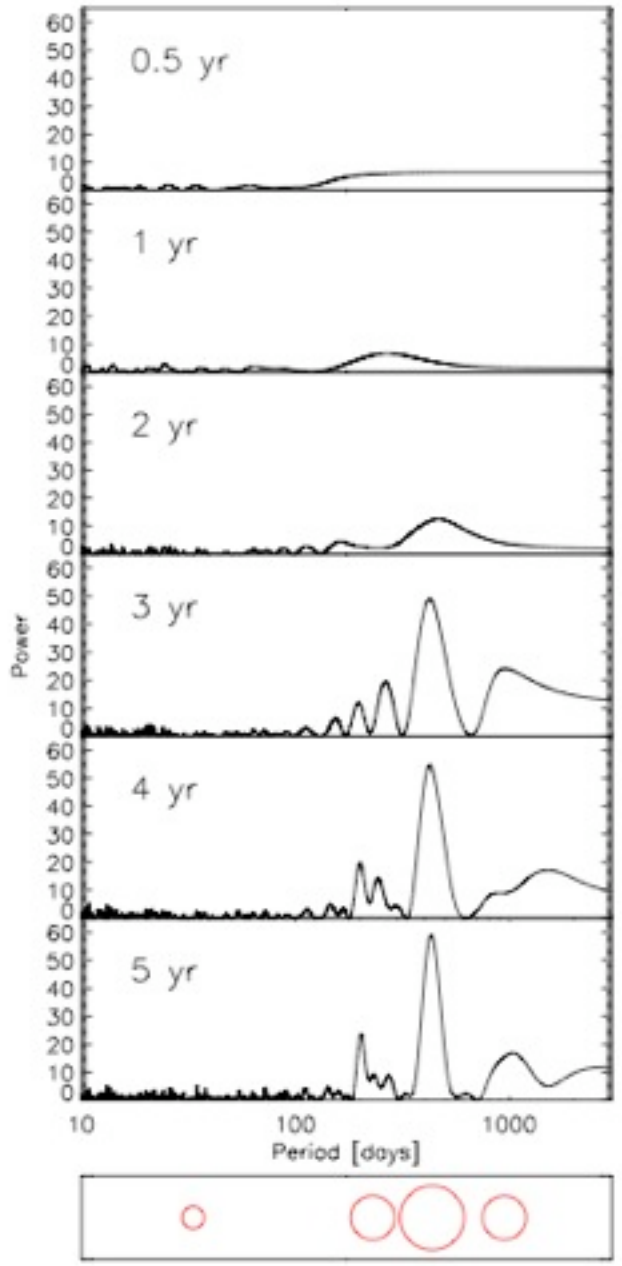
Mount Wilson Observatory
Carnegie Institution of Washington



i=79.2
w=231.65
W=204.85
e=0.5179
P=79.01 yr
V_A= 0
V_B=1.3
M_A=1.105 M_{sun}
M_B=0.934 M_{sun}



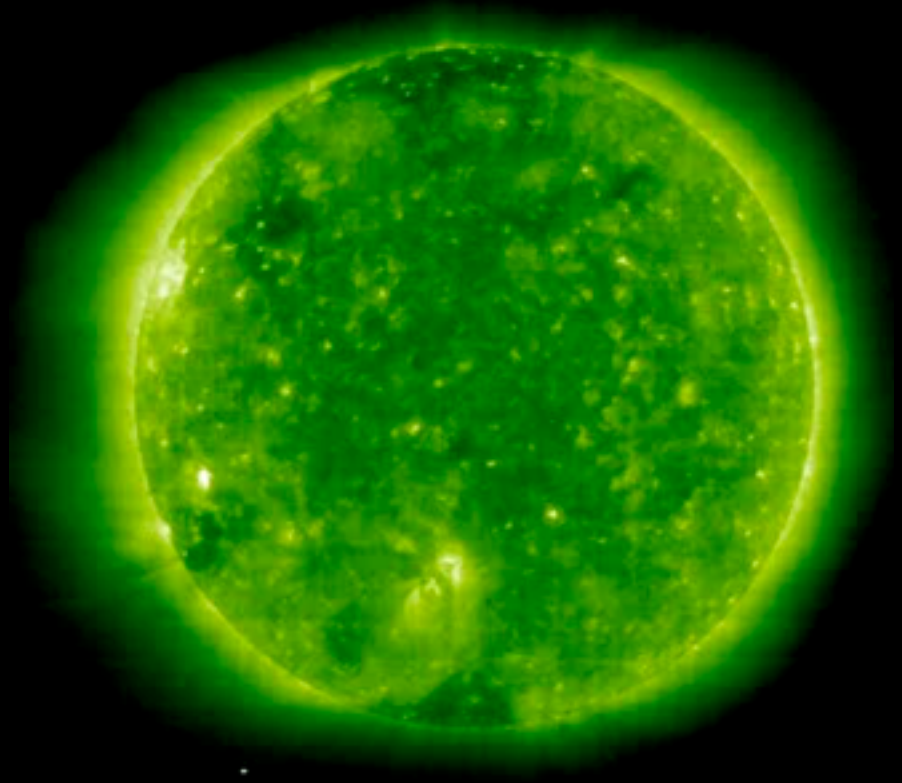
Planet Formation and Detectability Simulations for α Cen A and B



Simulations show: with 90 000 observations at a precision of 3 m/s, we'll beat down "white" stellar and instrumental noise to detect a Mercury + Venus + Earth in 4-5 years.

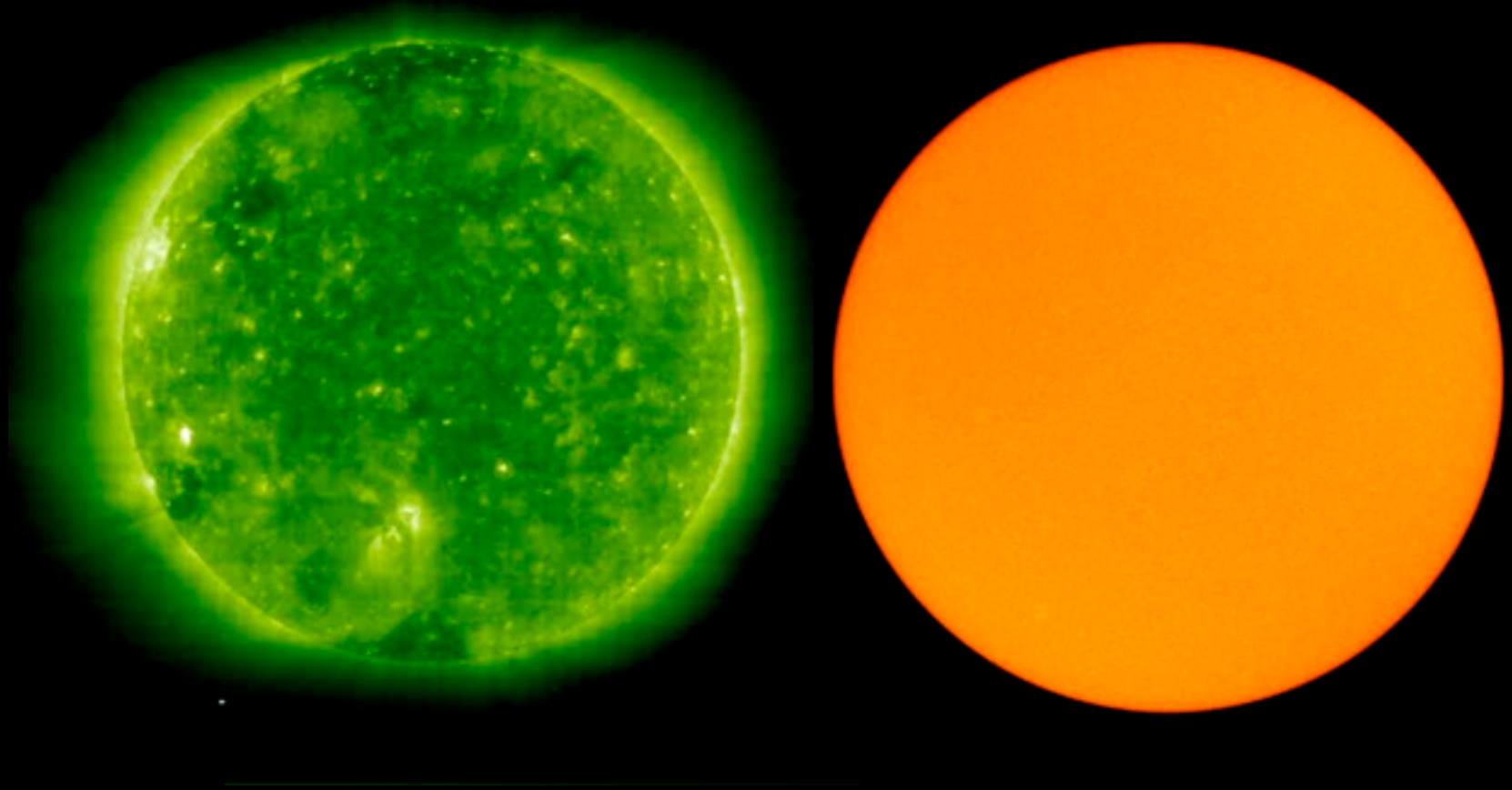
"Project Longshot"

Challenge: *velocity noise from the stellar surface*



Longshot because we don't know if stellar noise will average down.

Challenge: *velocity noise from the stellar surface*



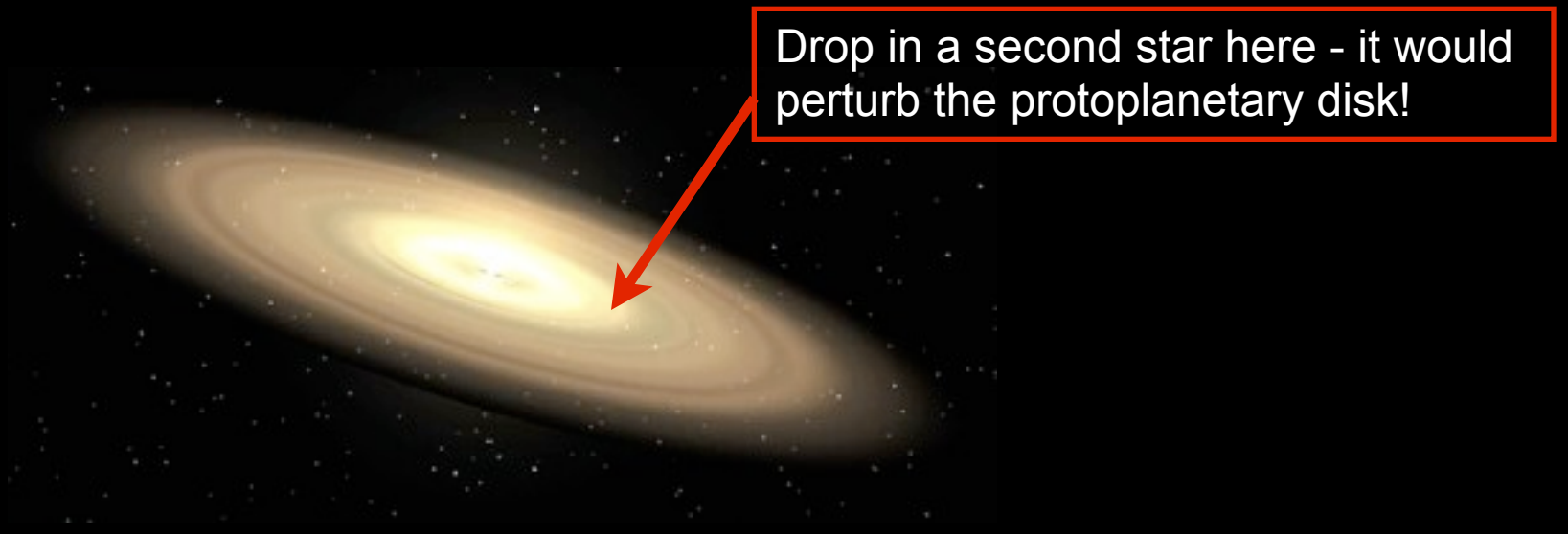
Longshot because we don't know if stellar noise will average down.

Exploring ways to work at redder wavelengths,
where the starspot contrast is low

Challenge: theory suggests that planets couldn't have formed in this close binary system

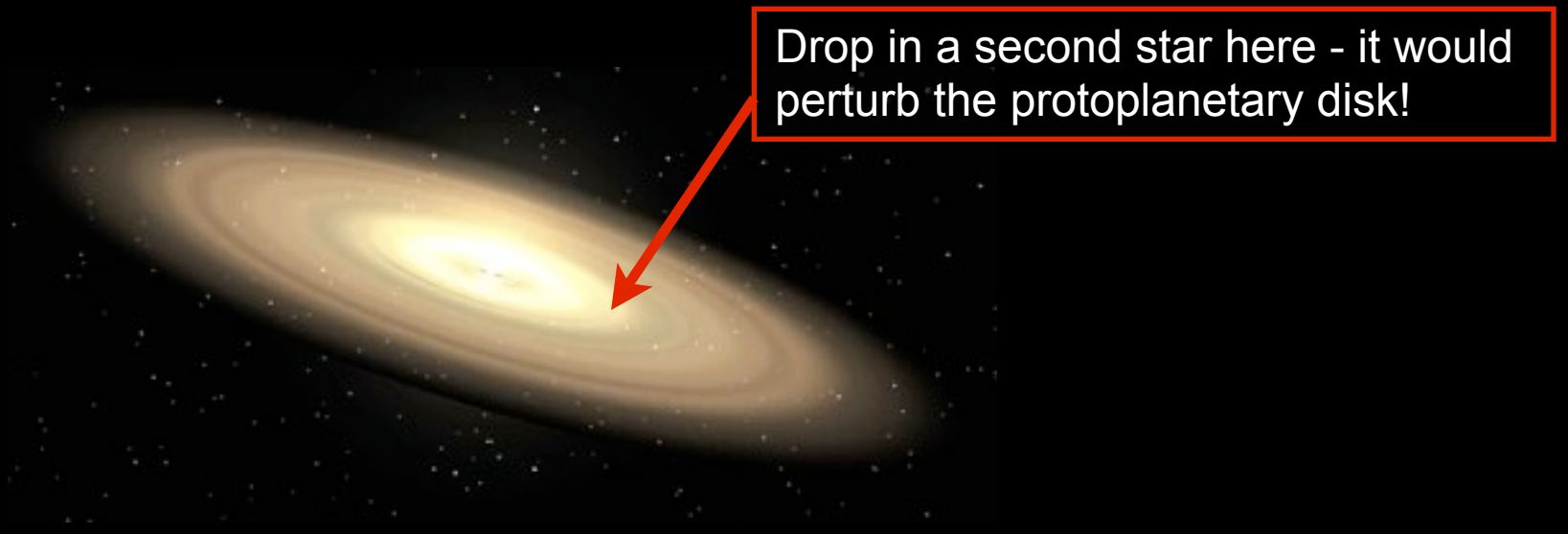
Longshot because we don't know if planets could have formed in this binary star system

Challenge: theory suggests that planets couldn't have formed in this close binary system



Longshot because we don't know if planets could have formed in this binary star system

Challenge: theory suggests that planets couldn't have formed in this close binary system

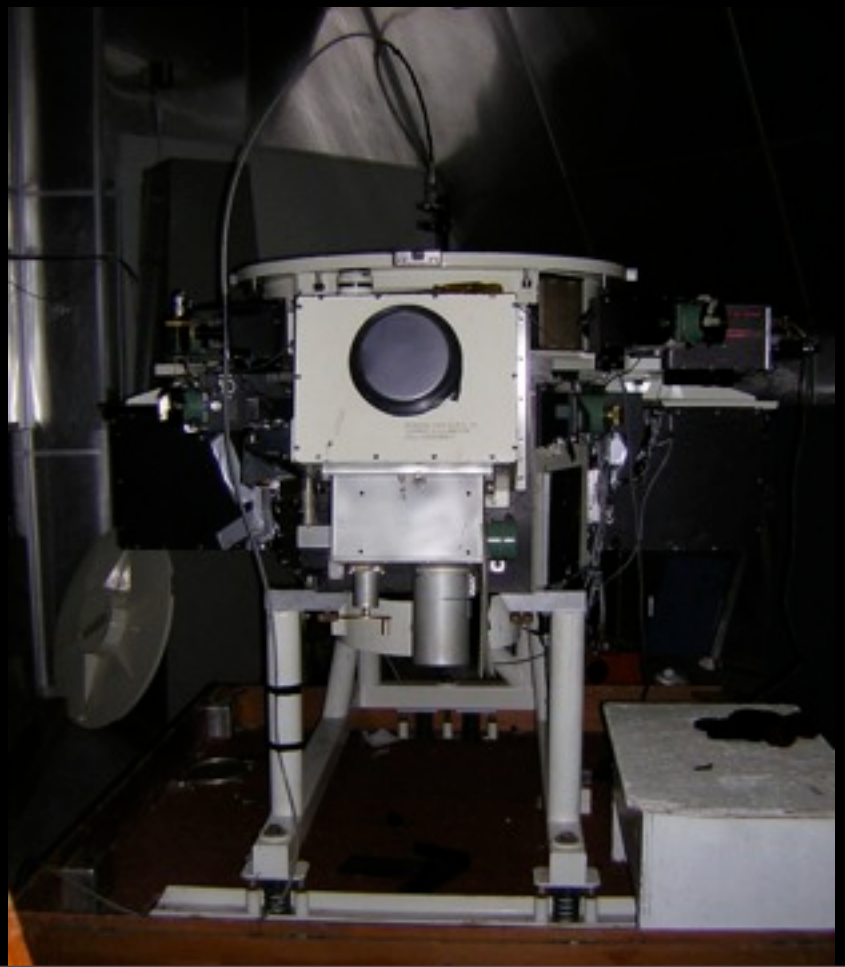


Longshot because we don't know if planets could have formed in this binary star system

Never listen to the theorists! They've been wrong before.
We have counter examples where planets have been found in close binary systems.

Challenge: keep this vintage spectrometer stable

Longshot because we need to push our technique to the limit with a 1980's spectrometer.



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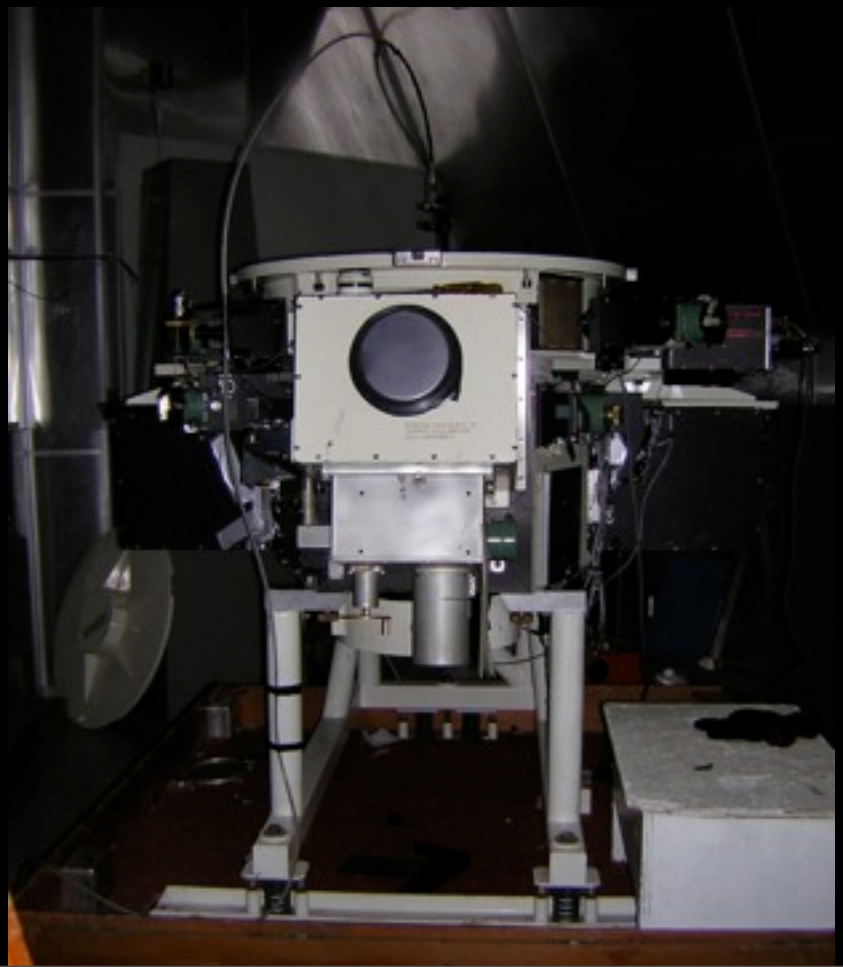
Longshot because we need to push our technique to the limit with a 1980's spectrometer.

NSF "stimulus" funding to build a new spectrometer - commission Dec 2010.



.... a Longshot, but some fool should really do it...

-1.06193
-1.16733
-0.417407
1.92958
3.17988
-1.74791
-1.78114
-3.20904
-0.866956
5.01716
2.60255
-4.47131
-0.978221
-1.27518
0.138991
-1.66309
0.822166
-1.61368
-4.78459
-2.20756
-3.05104
0.835631
-7.96410
-2.04525
-1.24991
2.94383
2.82318
3.67331
1.60848
-1.91629
2.87959
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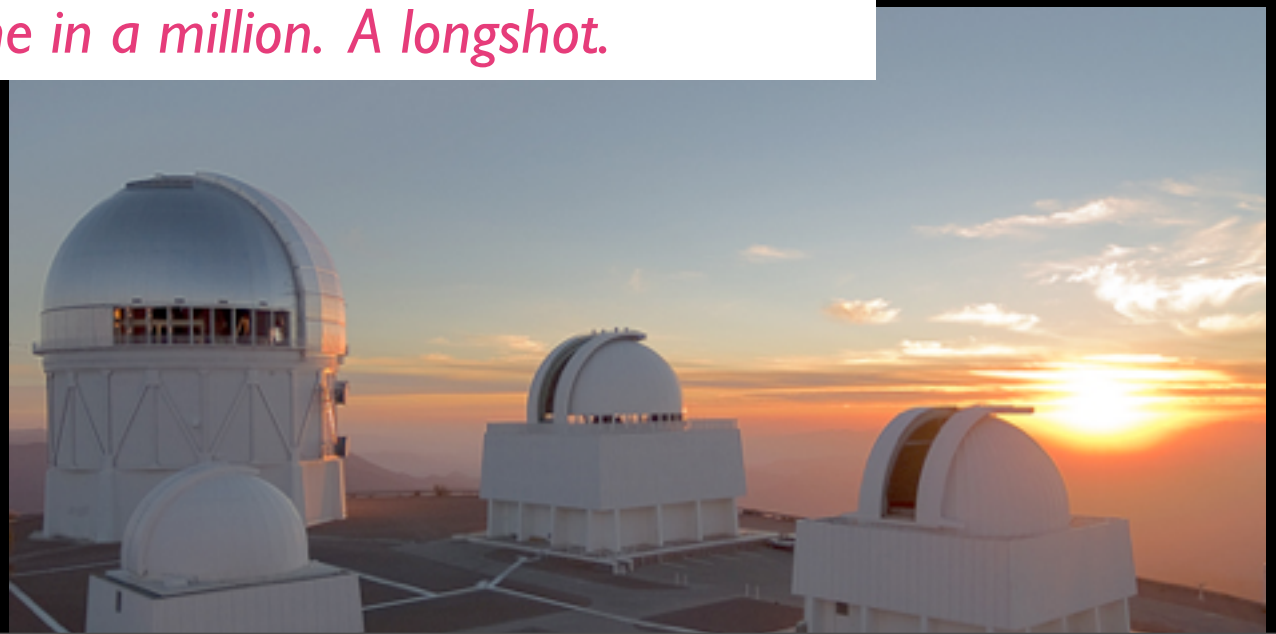
.... a Longshot, but some fool should really do it...

Frank Drake estimated his chances of finding extraterrestrial signals "somewhere between 25% and one in a million. A longshot.



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